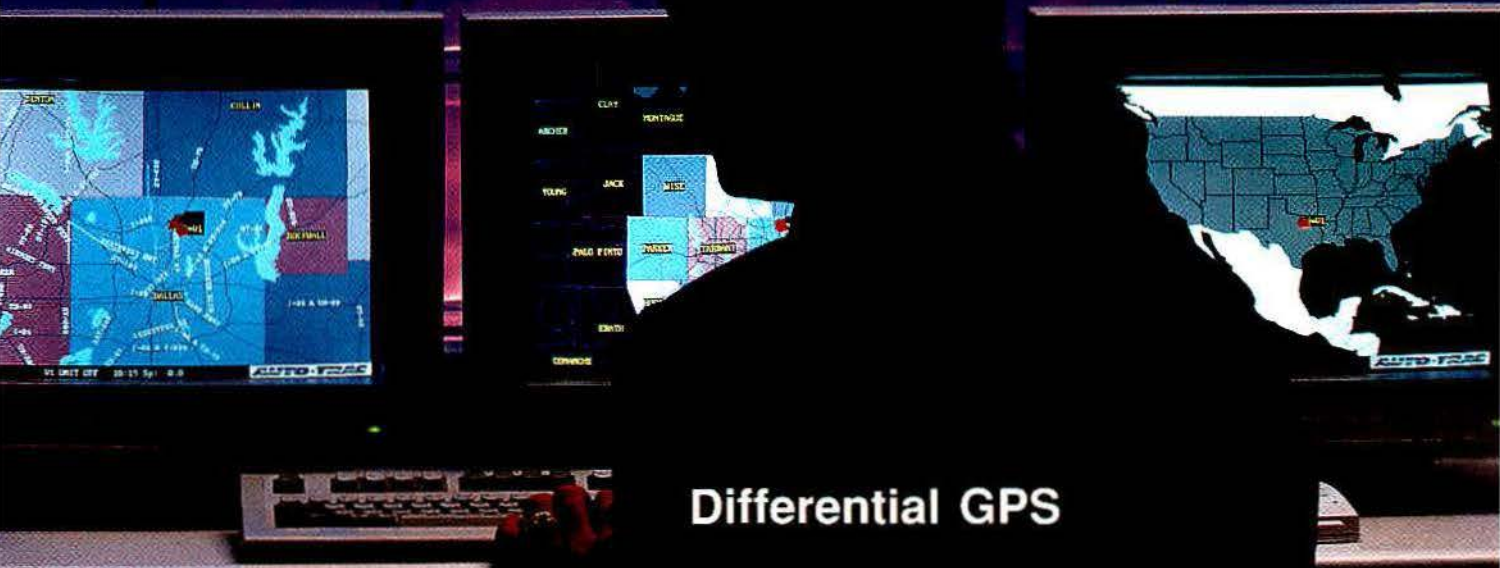


February 1994/\$3.00

# Mobile Radio Technology™

The journal of mobile communications technology

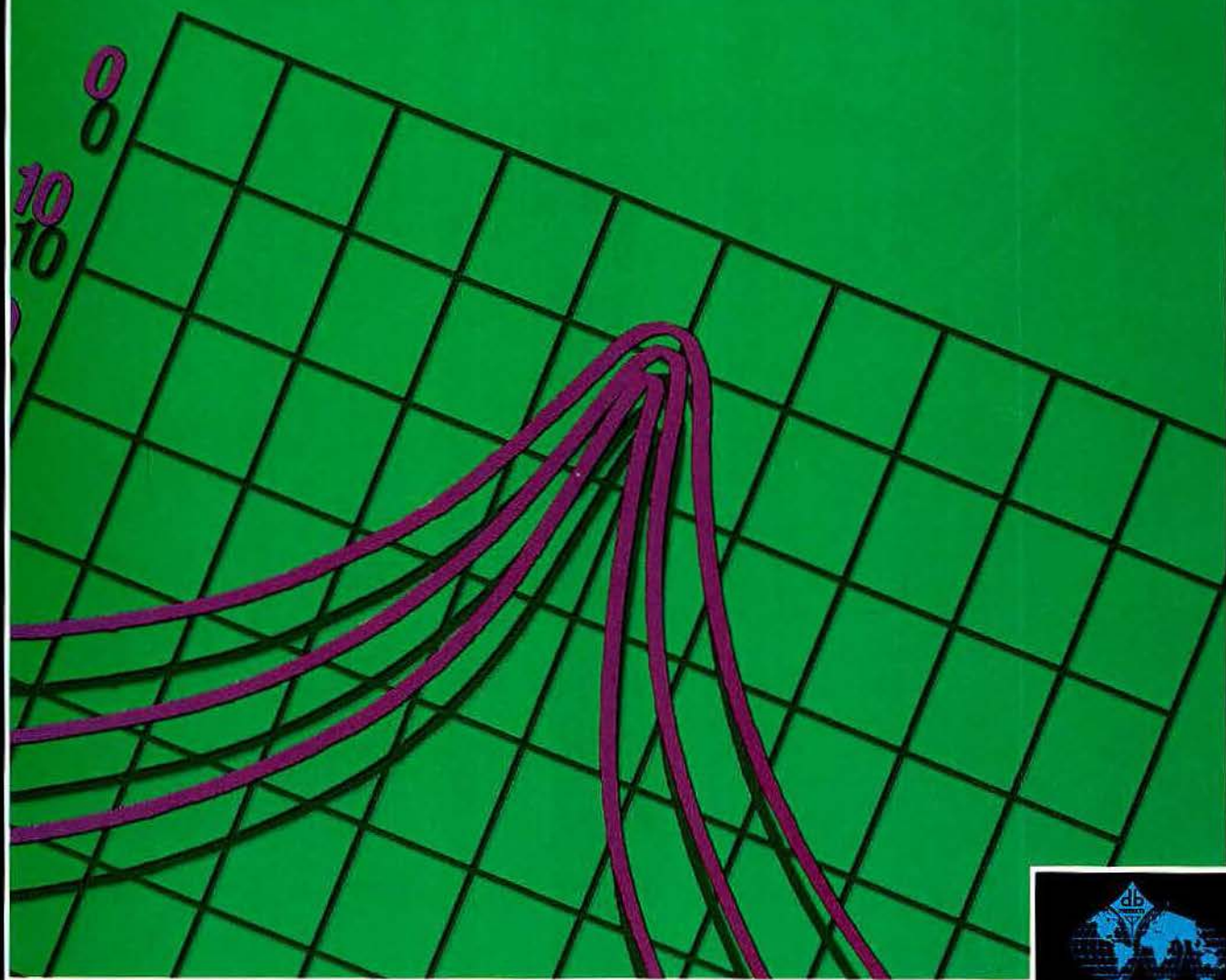


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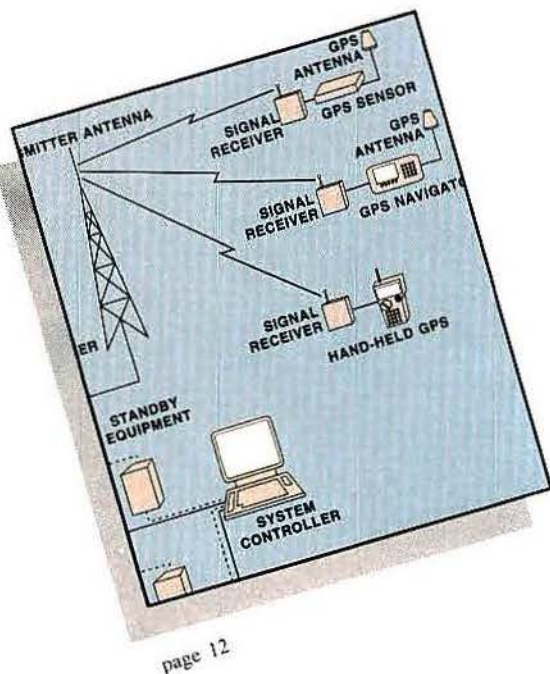
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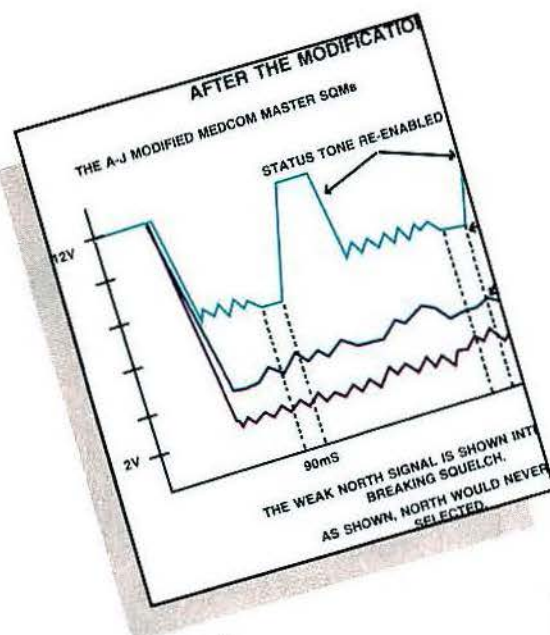
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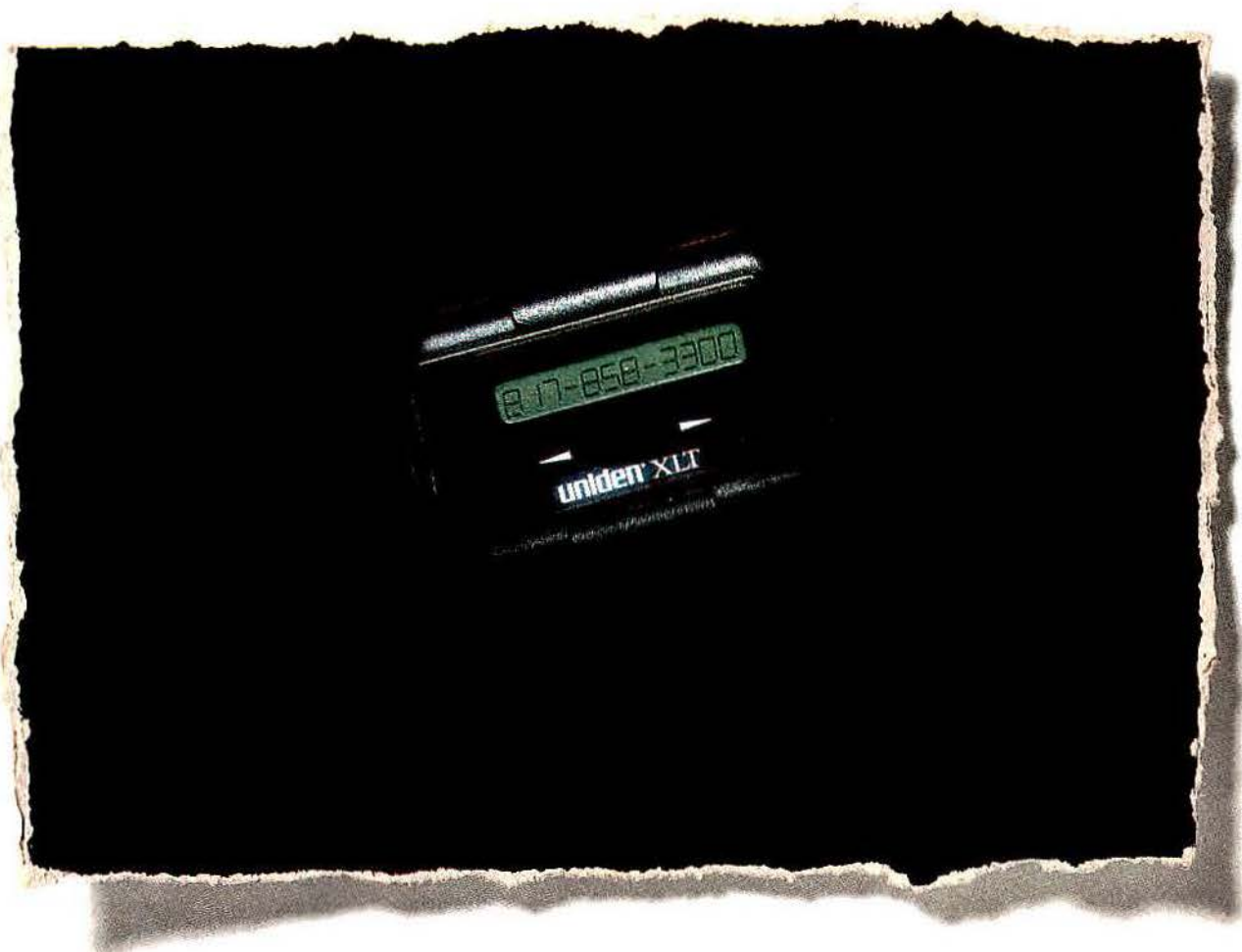


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**On the cover:** A view of the control center for Auto-Trac's real-time automatic vehicle location (AVL) system. All of the company's AVL systems use the Global Positioning System (GPS). Differential GPS can be used to boost accuracy. Photo courtesy of Auto-Trac, Dallas.



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## Scanning . . .



### Denver office relocates

It's moving time for Intertec Publishing's Denver office.

Our publisher, Mercy Contreras, and regional marketing managers Ruth Breashears (Northeast region), Carla M. Gamino (Southeast region) and Diane Hite (Midwest/Southwest region), are relocating to a new office at 5660 Greenwood Plaza Blvd., Suite 350, Englewood, CO 80111; tel. 303-793-0448; fax 303-793-0454, effective Jan. 29.

In 1993, Intertec acquired three more magazines, *The Press*, *Stitches* and *Tinta e Hilo*, from Wiesner Publishing, Englewood, CO. The new office thus consolidates the Intertec staff working in the Denver area.

We say "three more magazines" because, in November 1986, Intertec made its first purchase from Wiesner: *Mobile Radio Technology*, *MRT International* and *TeleCarrier* magazines.

(*MRT International* was discontinued and superseded by expanded worldwide coverage in Intertec's *Cellular & Mobile International*. *TeleCarrier*, which covered cellular mobile telephone and radiopaging, was discontinued as well, in part because Intertec already covered cellular with *Cellular Business*.)

Familiar names:

After many years of high visibility in the mobile communications industry as a publisher, Pat Wiesner, the president of Wiesner Publishing, disappeared from the scene when he sold the three magazines in 1986. Now you know part of what he has been doing: He continues to start, buy and sell magazines.

Pat's son, Dan Wiesner, an account executive with *MRT* before the 1986 Intertec purchase and a regional marketing manager for *MRT* and *Cellular Business* for a time afterward, later rejoined Wiesner Publishing and became publisher of *Stitches*. He returns to Intertec in that capacity.

Craig Howson, whom you would remember as managing editor of an *MRT* competitor, *RCR*, later became editor of *The Press*, and he joins Intertec in that capacity. Nancy Kuehl, who once was *RCR*'s research editor, joins Intertec in her current role as senior associate editor of *Stitches*.

We welcome our new colleagues and old friends.

\* \* \*

### Russian markets

The first we heard about private mobile

radio equipment sales to Russia since the breakup of the Soviet Union involved two-way radio equipment for law enforcement agencies in Moscow. That was a couple of years ago.

More recently, the construction of a privately owned radiopaging system to offer service to the public in a large Russian port city was announced.

This morning (Jan. 6), word arrived that Radio Shack is opening its first store in Russia.

Many U.S.-based wireless equipment manufacturing companies are benefiting from export sales. The increased visibility for wireless communications generated by stores such as Radio Shack in markets similar to Russia may help to pave the way for sales by these industrial, business and public safety communications equipment manufacturers.

If you have some overseas projects that you would like to publicize, let us know.

\* \* \*

### Information superhighway

Several years ago, discussions of personal communications services (PCS) first found their way into conferences and publications. Few people then knew what PCS was, and opinions about it still differ.

Now the hot topic is the "information superhighway." The information superhighway amounts to a 56,000-baud digital platform that can carry any information that can be coded in digital form, such as written information, sound and images.

Wire, fiber-optic cable, coaxial cable and microwave radio are among the media that offer bandwidth capacity for high-speed data. Unless specially configured, the narrow bandwidths normally used in two-way radio, radiopaging and cellular telephone are less suitable.

As people get used to transferring larger and larger amounts of data, the demand for storage and processing capacity will increase. That may lead to a resurgence in the need for mainframe computers.

Meanwhile, this information superhighway will need "on ramps" and "off ramps," a requirement that may be fulfilled by wireless services that otherwise do not have 56,000-baud capacity. It often happens that new communications systems rely on radio technology in either a central or a supporting role, and we expect that the information superhighway will provide another boost for the mobile radio communications industry.

—Don Bishop



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7-8—**AMTEX**, the American Mobile Telecommunications Association's Marketing and Technology Conference and Exposition, Marriott on International Drive, Orlando, FL. Contact: 202-331-7773.

## March

2-4—**Cellular Telecommunications Industry Association Winter Meeting and Exposition**, San Diego. Contact: 202-785-0081.

6-9—**Energy Telecommunications and Electrical Association**, Henry B. Gonzales Convention Center, San Antonio. Contact: 214-235-0655.

## April

13-15—**International Wireless Communications Expo/Spring**, Las Vegas Convention Center, Las Vegas. Contact: 1-800-828-0420.

## May

2-5—**Supercomm**, sponsored by USTA and TIA, and **International Conference on Communications**, sponsored by IEEE, New Orleans. Contact: USTA, 202-835-3100.

12-14—**Mobile Communications Conference**, sponsored by the National Association of Business and Educational Radio (NABER), Peabody Hotel, Orlando, FL. Contact: Nancy Palleschi, 800-759-0300.

25-27—**RadioComm**, Vancouver Convention Center, Vancouver, British Columbia. Contact: Bill Eggertson, 613-233-4888.

## June

7-11—**Vehicular Technology Conference**, sponsored by IEEE Vehicular Technology Society, Stockholm, Sweden. Contact: Professor Sven-Olof Ohrvik, technical chairman, 46 8 757 0483; Fax 46 8 34 8441.

18-20—**International Public Safety Exposition and Conference**, sponsored by the International Association for Public Safety, Dallas Convention Center, Dallas. Contact: 203-847-9679.

19-23—**Utilities Telecommunications Council**, Washington Sheraton, Washington, DC. Contact: Christine Benz, 202-872-0030.

## July

17-20—**Forestry-Conservation Communications Association**, Hershey, PA. Contact: Don Pfohl, 602-644-3166.

## August

6-11—**International Municipal Signal Association**, Cavanaugh's Inn, Spokane, WA. Contact: Harold Glerum, 800-723-4672.

7-12—**Associated Public-Safety Communications Officers National Conference**, Lawrence Convention Center, Pittsburgh. Contact: 800-824-1850.

## September

22-24—**Mobile Communications Marketplace**, Washington State Convention Center, Seattle. Contact: 800-326-8638.

## October

3-5—**WirelessWorld Conference & Exhibition**, sponsored by *Cellular Business* magazine, The Stouffer Orlando Resort, Orlando, FL. Contact: Stephanie Hanaway, 913-967-1856.

15-20—**International Association of Chiefs of Police**, Albuquerque Convention Center, Albuquerque, NM. Contact: 703-243-6500.

19-21—**International Wireless Communications Expo/Fall**, Tampa Convention Center, Tampa, FL. Contact: 303-220-0600.

## November

18—**Radio Club of America**, Communications Symposium, Annual Dinner and Awards Presentation, New York Athletic Club, New York. Contact: Ron Formella, 201-652-6811.

## 1995

### February

1-3—**Cellular Telecommunications Industry Association Winter Meeting and Exposition**, New Orleans. Contact: 202-785-0081.



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The journal of mobile communications technology

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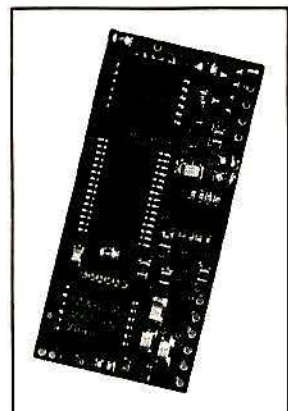
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## Using RF combiner and divider networks

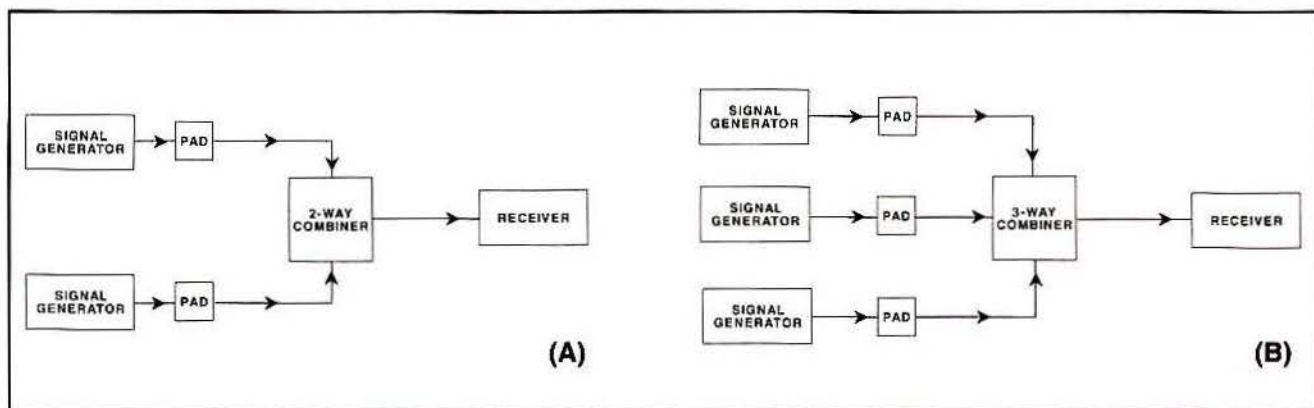


Figure 1. The test setup at (A) uses a two-way combiner-splitter device to couple two signal generators to a single receiver input. This setup is commonly used in performing the adjacent-channel selectivity and desensitization test on a receiver. At (B), a three-way combiner-splitter is used to couple three signal generators to a single receiver input. This

setup is used to perform the intermodulation rejection test on a receiver. The combiners serve to provide a proper impedance match and to isolate the signal generators from each other. This minimizes any adverse interaction between them that might invalidate the test procedure results.

By Harold Kinley, CET

Certain testing techniques require combining several outputs (sources) to a single input (load). Conversely, sometimes it is desirable to divide a single input to form two or more outputs. (See Figures 1A and 1B above.)

In Figure 1A, outputs from two signal generators are combined and fed to the input of a single receiver. Such a setup is required to perform an adjacent-channel rejection and desensitization test.

In Figure 1B, outputs from three signal

generators are combined and fed to the input of a single receiver. This setup is required to perform an intermodulation rejection test on a receiver.

### Resistive networks

Splitting or combining signals can be done with either resistive networks or networks using RF transformers (along with resistors).

Resistive networks are simple to design and easy to fabricate in the shop. Figure 2 below shows how to design a three-port, or two-way, splitter-combiner such as the one that might be used in Figure 1A. All resis-

tance values are equal because the design is symmetrical. Any port can serve as input or output.

The formula for finding the resistance value is shown in Figure 2 along with the formula for finding the loss in decibels

(continued on page 58)

Kinley is a certified electronics technician with the South Carolina Forestry Commission, Spartanburg, SC. He is the author of *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*, Prentice-Hall, 1985.

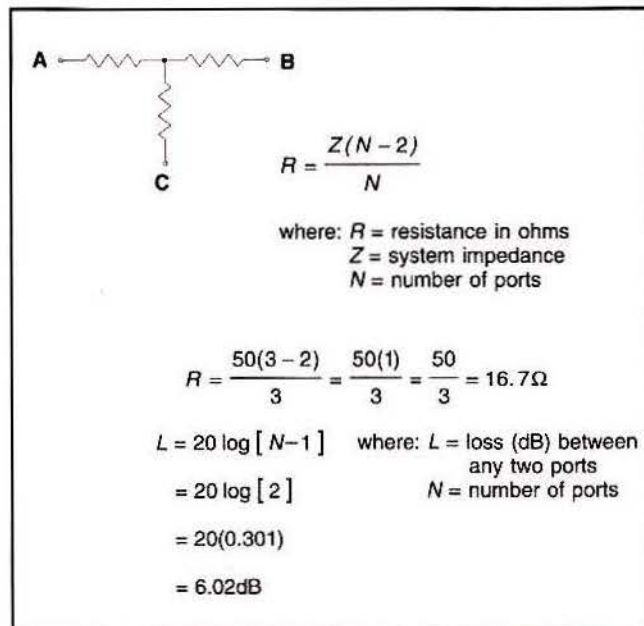


Figure 2. This simple resistive combiner-splitter can be used to combine two signal sources to a single input or, vice versa, to split a single input into two outputs.

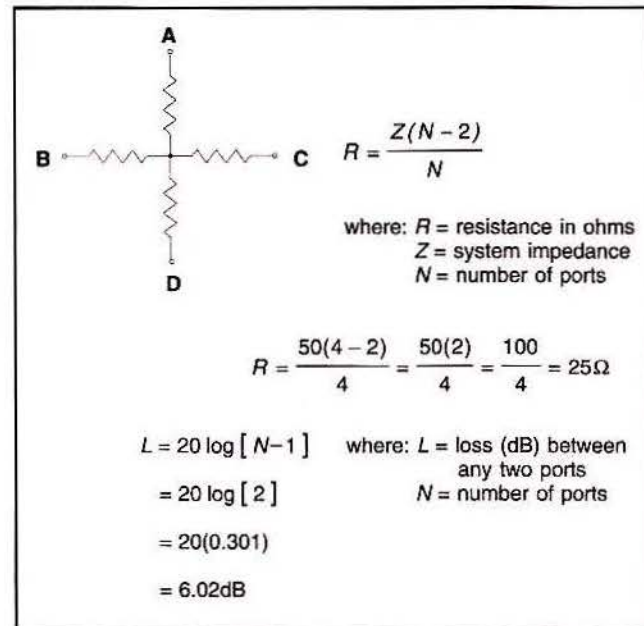


Figure 3. This three-way combiner-splitter combines 3:1 or splits 1:3.



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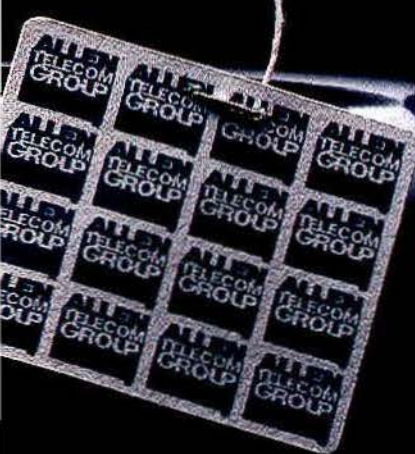
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# FM subcarrier network extends differential GPS nationwide

*Using a network with 320 FM broadcast subcarriers, a new subscription service extends differential Global Positioning System capability across the continent, opening a vast market for high-accuracy positioning services.*

By Michael Etherington

For a number of years now, FM radio stations have made their subcarriers available to support a wide range of commercial and public services.

Subcarriers—frequencies within the station's licensed bandwidth on either side of the main broadcast band—often are used to transmit piped-in "elevator music," stock quotations, "books for the blind" and paging signals.

Now, in a growing number of cities across North America, FM subcarriers

also are being used to transmit navigation signals that will permit you to determine your geographic position within a few feet. (See Figure 1 below.)

Last year, Magnavox Electronic Systems and CUE Network joined forces to launch a nationwide, low-cost, real-time satellite positioning system that uses signals from U.S. military satellites together with error-correction data broadcast over FM subcarriers. The subscription-based service is being marketed under the trade name Acc-Q-Point.

## Global Positioning System

The subscription service uses the Global Positioning System (GPS), which was developed by the U.S. Department of Defense (DOD) to provide navigation and

guidance for U.S. military forces and weapon systems.

Although GPS is primarily a military space program, it also has widespread commercial potential, and the DOD is committed to making GPS freely available to the general public, albeit at a slightly lower level of accuracy than that available to the armed forces.

GPS consists of a constellation of 21 satellites, plus several in-orbit spares, circling the globe about 12,500 miles above the earth. Their orbital planes are organized so that four or more satellites are visible simultaneously from any point on the earth's surface.

Each satellite broadcasts a navigation message on two L-band frequencies, L1 (1.57542GHz) and L2 (1.2276GHz). The

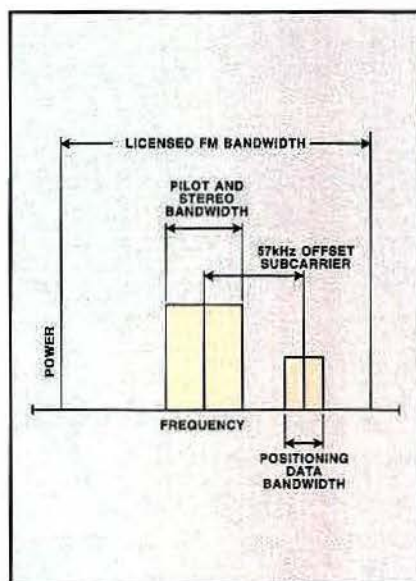


Figure 1. FM broadcast subcarriers in CUE's nationwide network transmit navigation signals to help determine geographic positions within a few feet. Most FM stations in the network use 50,000W or 100,000W power, and 10% to 20% of that power may be diverted into the subcarrier.

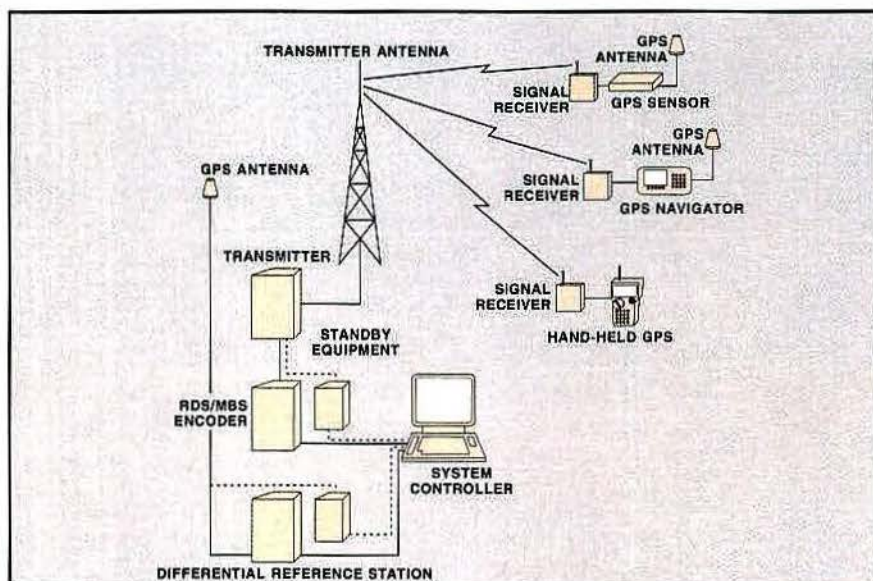
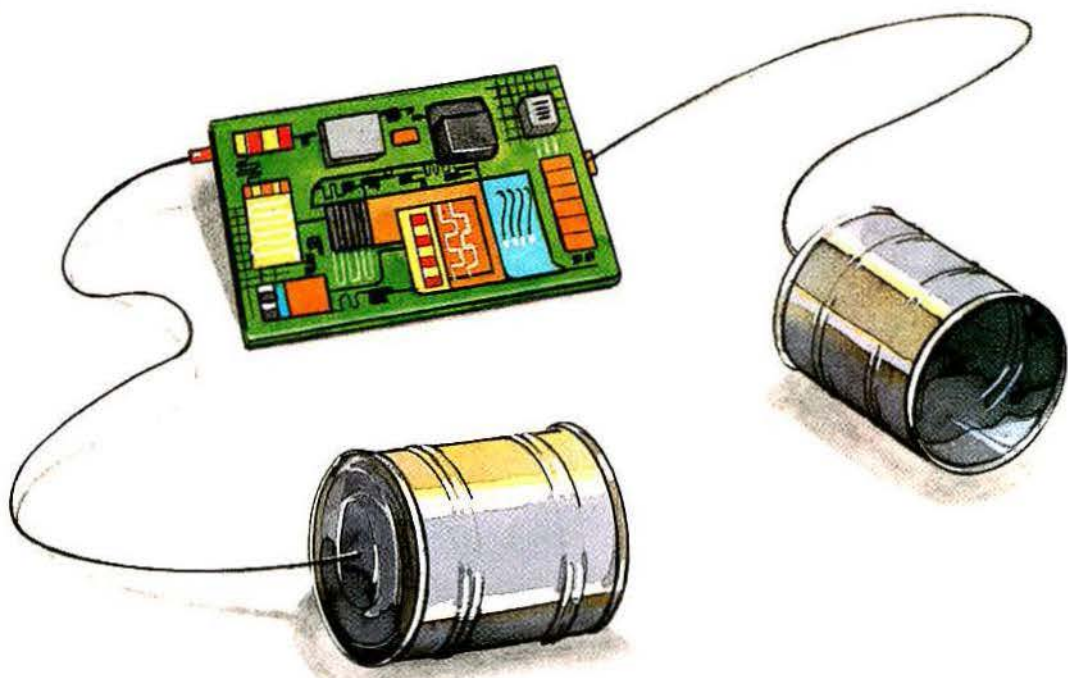


Figure 2. GPS accuracy can be improved substantially by using a technique called *differential navigation*. Location information from a GPS receiver at a precisely known fixed site is compared with the calculated position from the satellites to measure errors in each satellite's signal. Correction factors then are broadcast via a radio data link to mobile users.





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L1 carrier is modulated with a coarse acquisition (C/A) code with a frequency of 1.023GHz. Both the L1 and L2 frequencies also are modulated by a second code, called the P-Code, which has a much faster switching rate of 10.23MHz.

Both codes carry a navigation satellite message with a data rate of 50bps. This message contains the satellite's exact position in space and a precise time signal derived from its atomic clock.

A GPS receiver determines its position in three dimensions (latitude, longitude and altitude) by measuring the time of arrival of signals from the orbiting satellites. Because the radio signals move at a constant speed through the air, the receiver is able to decode the navigation message and solve the time-speed-distance equation to calculate the distance, or range, to each satellite, yielding lines of position which intersect at the receiver's

geographical location.

To do this, it is necessary for the GPS receiver to synchronize its internal clock precisely with the time signal from the satellite. Thus, the receiver must use signals from at least four satellites to obtain a three-dimensional position fix (three for latitude, longitude and altitude, and the fourth to resolve the internal clock errors).

If the receiver's altitude is known or unimportant (e.g., for most surface applications) only three satellite measurements are needed instead of four.

To prevent enemy military forces from using GPS to guide missiles and bombs onto U.S. targets, the DOD is making the system's full accuracy available only for authorized military users. Accuracy is degraded for civilian users under a program called Selective Availability. The accuracy is degraded by limiting access to the P-Code and by dithering the clock and orbital parameters in the satellite's navigation message, thereby introducing errors in the GPS receiver's position fix calculations.

These errors are rapidly changing and randomly applied, making them impossible to predict and model. Authorized military users will be given classified decryption keys to provide access to full system accuracy.

Thus, there are two levels of GPS accuracy. Military users have access to the Precise Positioning Service (PPS), which is capable of yielding accuracies to within 66 feet. Non-military users, on the other hand, get access to the Standard Positioning Service (SPS) with a predictable geographical accuracy to within 328 feet, with a 95% certainty factor. In other words, 95% of all position fixes will fall inside a circle whose radius is 328 feet from the true position.

#### Differential GPS

For many potential users of GPS, 100 meters is not good enough.

Happily, GPS accuracy can be improved substantially by using a technique called *differential navigation*. This improvement is accomplished by placing a GPS receiver at a fixed site where the position is precisely known, for example, a geodetic mark or another surveyed location. (See Figure 2 on page 12.)

This receiver, called a reference station, monitors signals from all available GPS satellites. The reference station compares its known position to the calculated position from the satellites and uses the difference to measure errors in each satellite's signal.

The reference station then computes correction factors necessary to offset those



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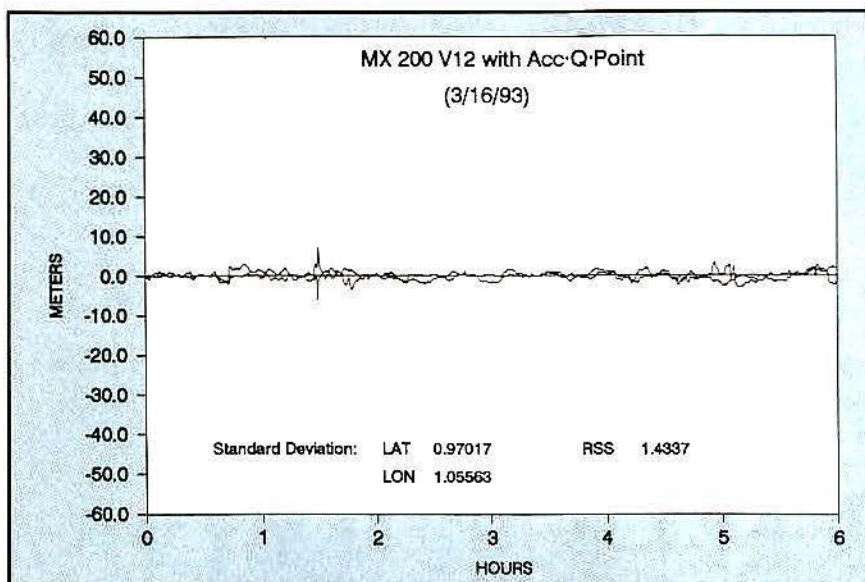


Figure 3. Differential GPS error corrections are fed into the mobile GPS receiver, which uses them to refine the navigation solution and to improve fix accuracy to better than 33 feet. With special refinements and signal processing techniques, accuracy can be improved down to inches.

errors and broadcasts correction data via a radio data link to mobile users. The error corrections are fed into the mobile GPS receiver, which uses them to refine the navigation solution and to improve fix

accuracy to within 33 feet. (See Figure 3 above.) In fact, with special refinements and signal processing techniques, accuracy can be improved down to inches.

Differential GPS (DGPS) cancels out the

errors introduced by Selective Availability, as well as those from atmospheric distortion and multipath interference. Because differential GPS is only effective over relatively small areas, typically less than 200 miles from the reference station, the DOD does not consider DGPS to be a threat to national security.

An industry trade association, the Radio Technical Commission for Maritime Services (RTCM) has taken the lead in developing an international standard to define the differential GPS data messages. Most modern GPS receivers are able to receive DGPS data in the RTCM-SC104 format.

#### Technical hurdle

Until now, the biggest technical hurdle to developing wide-area, low-cost differential GPS has been the data link needed to transmit the error corrections from the reference station to the mobile users.

In the United States, radio frequencies are subject to restrictive FCC licensing requirements, and frequency allocations are increasingly hard to obtain. Satellite data links are expensive, and land lines are impractical for users on the go. Thus, most differential GPS systems that have been deployed to date have been limited in

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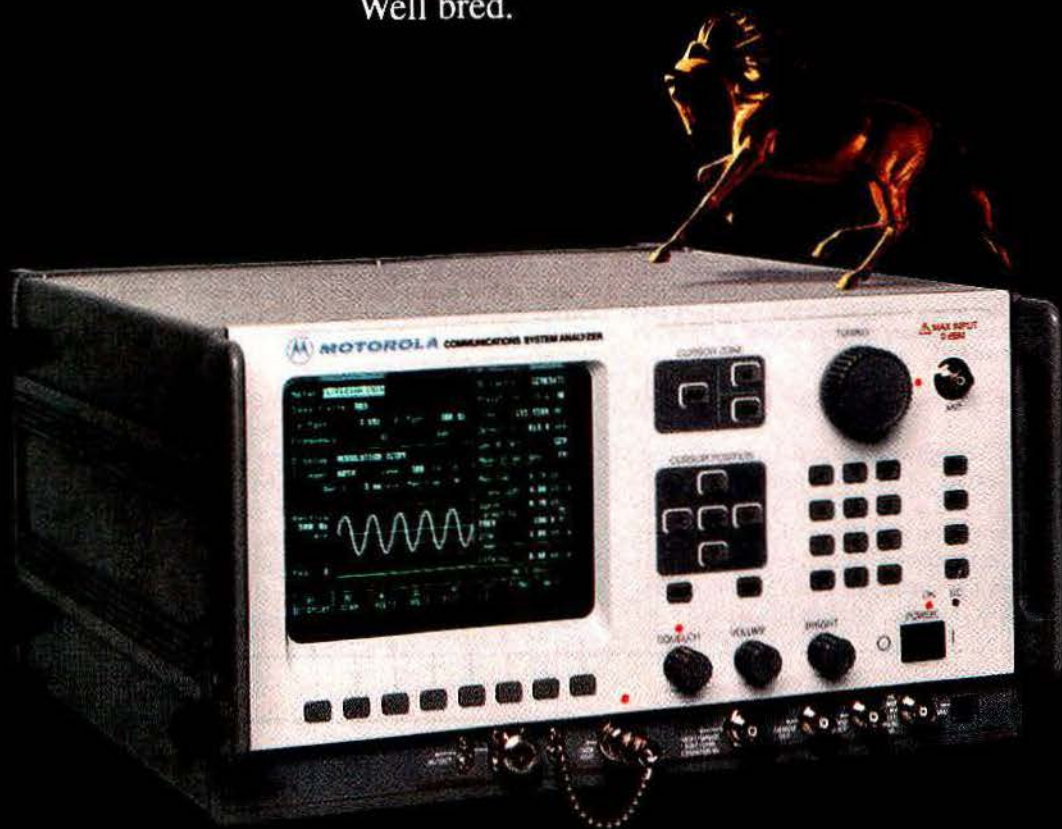




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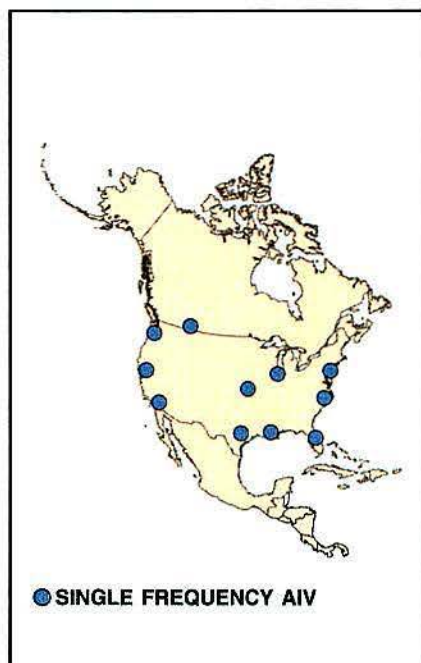


Figure 4. As of Oct. 1, 1993, service was available in 10 cities in the United States and Canada, using a single L-band frequency and with the necessary number of GPS satellites all in view (AIV).

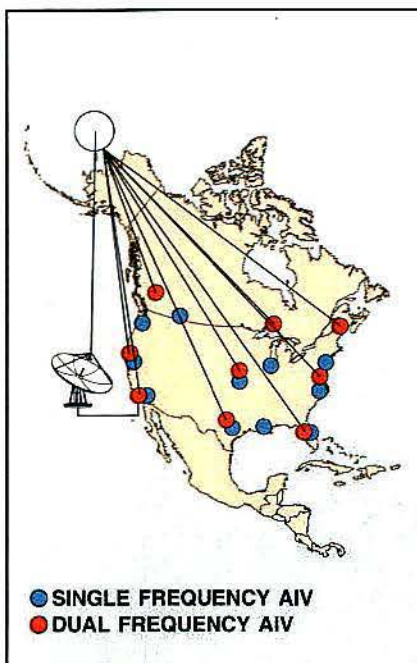


Figure 5. At least 10 more cities were expected to come on line by the end of 1993, some using a single L-band frequency, some with two.

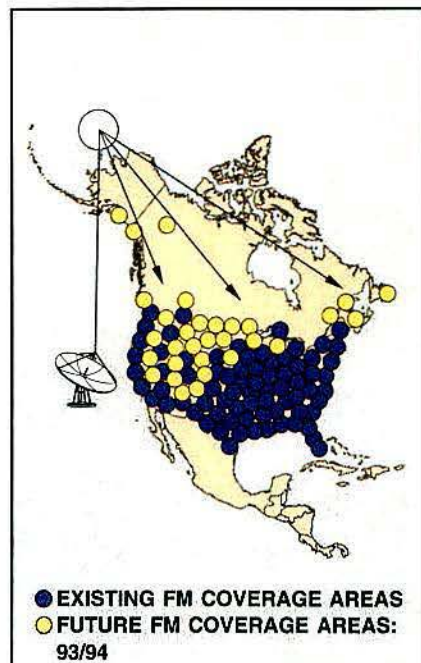


Figure 6. Ultimately, there will be about 320 subscription service broadcast sites covering more than 1 million square miles and 90% of the U.S. and Canadian population.

scope and very expensive to set up and use.

This brings us back to the new subscription service. It uses differential GPS technology and a network of more than 320 FM broadcast stations to distribute correction data from DGPS reference stations across the continent. The FM station network is in place, already having been de-

veloped to distribute paging signals to tens of thousands of customers. DGPS correction data are "piggy-backed" on the paging transmissions through the FM subcarriers.

Thus, the new subscription service solves the problem of the DGPS data link. FM subcarriers are ideal for broadcasting DGPS corrections. Their 88MHz-108MHz range is well above interference generated

by weather and man-made sources, and there is abundant FM subcarrier capacity available in most cities using powerful radio stations with as much as 100,000W of transmitting power.

Most important, the paging network's existing subcarrier-based paging system provides a ready-made nationwide infrastructure that can be adapted easily to DGPS. Because the subscription service's DGPS corrections can be compressed to a very narrow bandwidth, they can share the FM subcarrier with the paging transmissions without interfering with the paging signals or the FM broadcast band.

The subscription service was launched initially in the Los Angeles metropolitan area in February 1993. Since then, the system has rapidly expanded.

As of Oct. 1, 1993, service was available in 10 cities in the United States and Canada, using a single L-band frequency. (See Figure 4, above left.) At least 10 more cities were expected to come on line by the end of 1993. (See Figure 5, above center.)

Ultimately, there will be about 320 subscription service broadcast sites covering more than 1 million square miles and 90% of the U.S. and Canadian population. (See Figure 6, above right.)

The subscription service is being marketed in each service area through authorized dealers chosen on the basis of their experience with navigation and communication technology, their ability to provide

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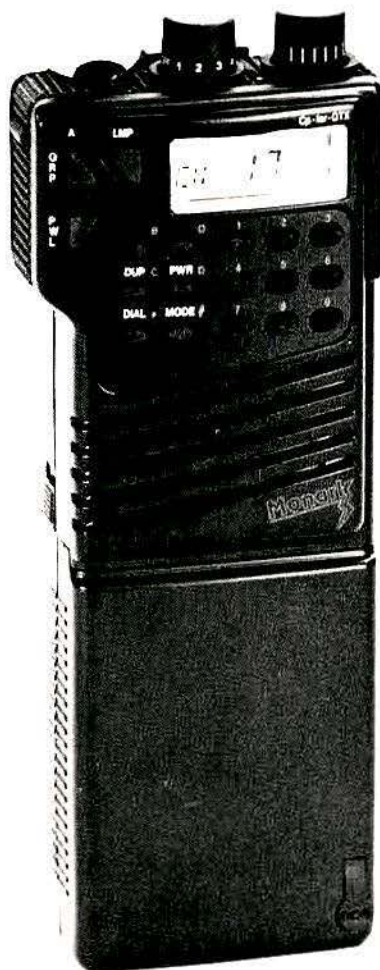
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adequate technical support to customers in their regions and their knowledge of potential markets.

Through this network of authorized dealers, subscribers can sign up for the subscription service in much the same way they would for paging services, on a monthly or yearly basis. There is a one-time activation fee of \$200, and subscription fees average about \$3.30 per day for each user. Special rates are available for fleet subscribers.

To access the data broadcasts, subscribers need a compact FM data receiver that sells for less than \$400 and that can be installed in a vehicle or hand-carried. The data receiver plugs directly into almost any commercially available GPS receiver capable of accepting data in the RTCM-SC104 format.

To achieve rapid and widespread market acceptance, the subscription service has been designed with an open architecture, so that it can be accessed by off-the-shelf GPS receivers from almost any manufacturer. The service already has been tested and found compatible with GPS receivers from several manufacturers, including Trimble, Magellan, Lowrance, Rockwell and Magnavox.

## Multibillion dollar market

Independent market research studies estimate the potential U.S. market for DGPS equipment and services to be as much as \$20 billion over the next 10 years.

That's right, \$20 billion.

Differential GPS is an enabling technology that will play a key role in the development of other emerging technologies, such as Automatic Vehicle Location Systems (AVLS), Intelligent Vehicle Highway Systems (IVHS) and Geographic Information Systems (GIS). By creating the first low-cost, open-ended infrastructure for differential GPS, the subscription service will serve as the catalyst for explosive growth in DGPS-based applications.

In the land mobile environment, the subscription service will be used for fleet tracking and management systems, especially for high-value vehicles such as ambulances and police cars, which typically require better accuracy than the 328 feet offered by raw GPS.

There are also large untapped markets for precise positioning technology in agribusiness, civil construction, surveying, transportation planning, natural resource management and utility management. Consider, for example, the market opportunities opened by using DGPS to create map-based databases of underground water mains, sewers, fiber-optic cables and other public utilities.

For cities in coastal regions, the FM-based DGPS signals can be used for precise vessel traffic control, dredging operations and hydrographic studies. One of the earliest major subscribers to the service was Chevron Shipping, which is using the service for safe maneuvering of large tankers through narrow channels on the West

Gulf Coasts. The DGPS broadcasts are usable as far as 65 miles to 80 miles offshore in most coastal areas.

There also will be considerable markets for the subscription service in aviation and aerospace. Differential GPS is being evaluated as an aid in instrument landings and tracking aircraft and vehicle movements on the ground at major airports

around the world. It is expected that DGPS will be a cost-effective alternative to very expensive ground-tracking radar systems and microwave landing systems.

In less than a year of operation, the subscription service has achieved rapid growth and strong market acceptance. The subscriber list includes major shipping companies, international oil companies, automotive manufacturers, state and regional government agencies and public utilities, in addition to many smaller engineering companies, survey companies and contractors engaged in special projects requiring reliable, accurate position inputs.

For qualified dealers and potential users alike, the subscription service represents an extraordinary opportunity to get involved with one of the hot growth technologies of the 1990s.

---

*Independent market  
research studies estimate  
the potential U.S. market  
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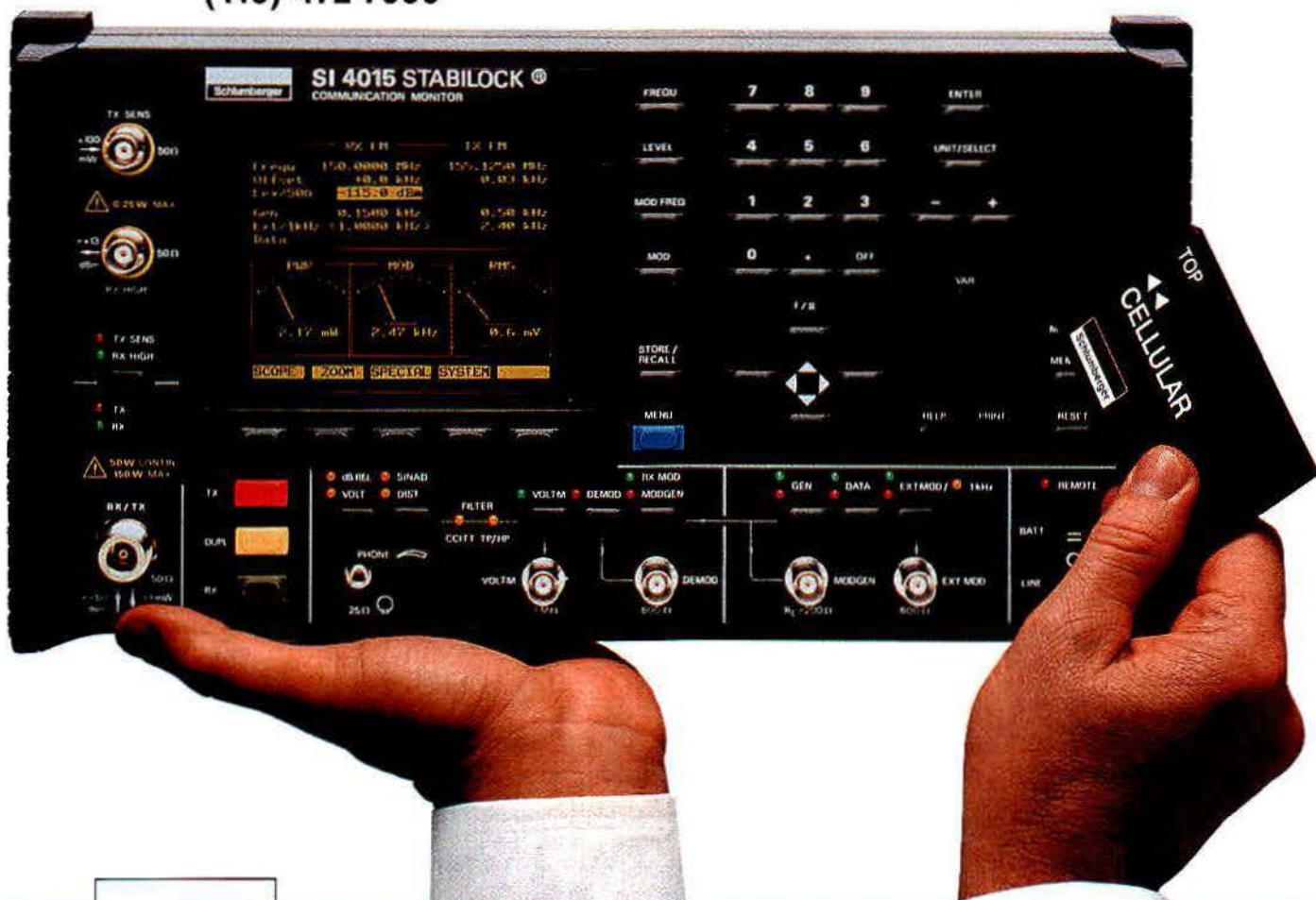
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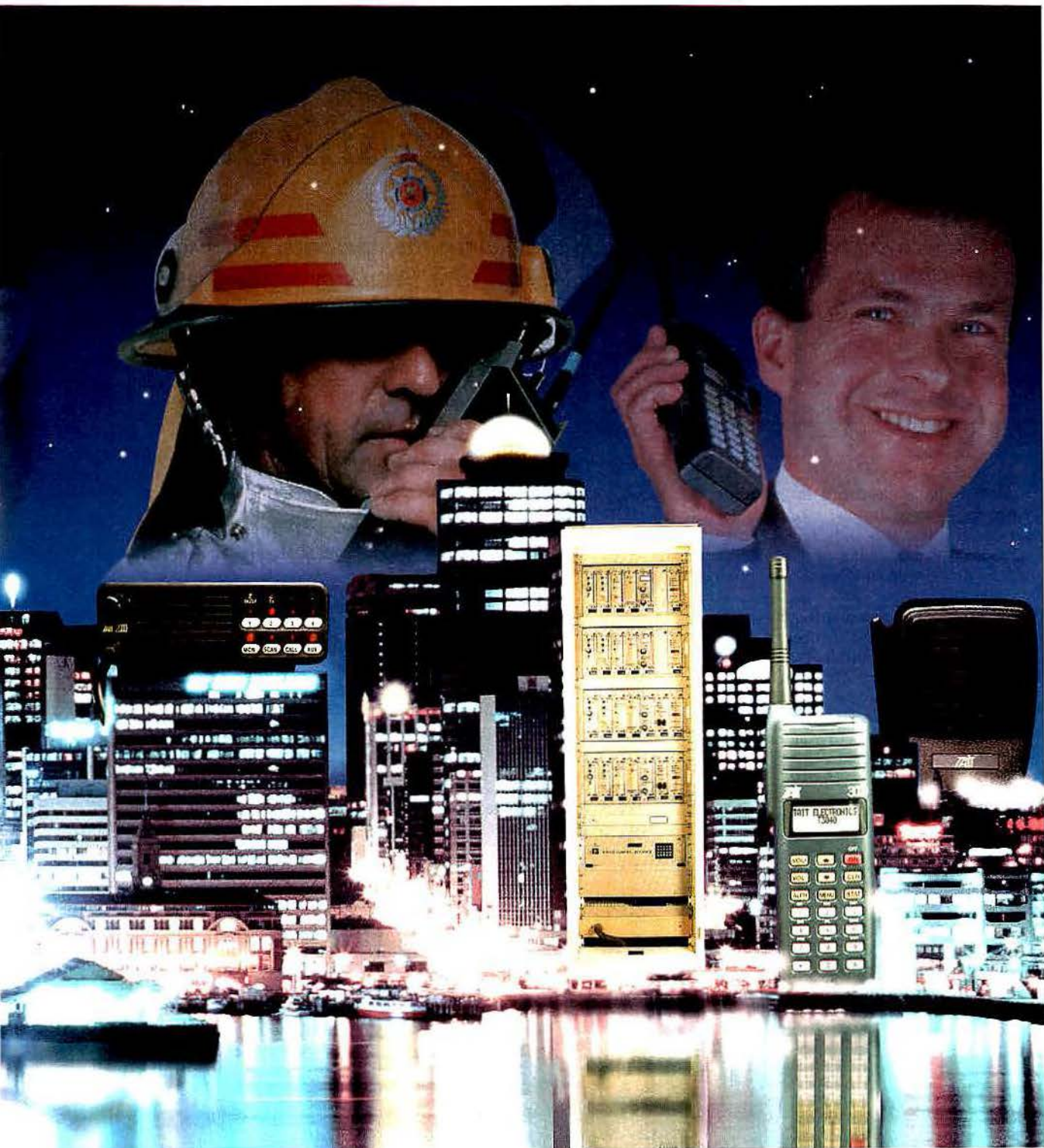
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# Time-saving tips for using service monitors

*Use two simple-to-implement aids to enhance the operation and usefulness of almost any service monitor. One helps with frequency measurements; the other helps to protect technicians' hearing from excessive audio levels.*

By E. Kirk Ellis

With the proliferation of split-frequency channels, it can be difficult to use an older service monitor that only receives frequencies with a resolution of three or four places after the decimal point.

## Frequency-error measurements

Our company uses a number of split-frequency channels, primarily for radio alarms and load control. One method I use to read these frequencies' errors exactly on a service monitor uses the following mathematical formulas. An example helps to show how to use them.

Ellis is a telecommunications technician with Carolina Power & Light, Raleigh, NC.

service monitor correction factor (CF)

= actual licensed frequency - service monitor

frequency setting

or

$CF = F(\text{licensed}) - F(\text{displayed})$

For example, a certain transmitter may be licensed to operate on 154.46375MHz. Let's say that the service monitor only can read to four significant places after the decimal, to the nearest 500Hz.

Set the service monitor to read the nearest frequency. Dial in 154.4635MHz. The correction factor for the frequency error measurement becomes:

$CF = 154.46375\text{MHz} - 154.4635\text{MHz}$   
= +250Hz.

If the transmitter is exactly on frequency, the service monitor displays an error of +250Hz. Such is rarely the case, though. That brings us to the second formula.

Actual frequency error (FE)

= Error read - CF

Lets say that the service monitor actually shows a reading of +300Hz. What is the actual frequency error?

$FE = 300\text{Hz} - 250\text{Hz} = +50\text{Hz}$

The transmitter is off-frequency by +50Hz, or the actual transmitted frequency is:

$154.463,750\text{Hz} + 50\text{Hz} = 154.4638\text{MHz}$

A second example may help to clarify the procedure: A technician uses an older service monitor to check a radio-alarm transmitter. The transmitter's licensed frequency is 173.39625MHz. How do we read frequency error with a service monitor that only reads to the nearest 5kHz?

First, set the service monitor as close as possible to the licensed frequency. This frequency is 173.395MHz.

Next, calculate the correction factor:

$CF = 173.39625\text{MHz} - 173.395\text{MHz}$   
= 1,250Hz

Key the transmitter and read the displayed frequency error. Suppose the frequency error displayed is 250Hz. The actual error and transmitted frequency are determined by the second formula:

$FE = 250\text{Hz} - 1,250\text{Hz} = -1,000\text{Hz}$

The transmitter is operating 1,000Hz

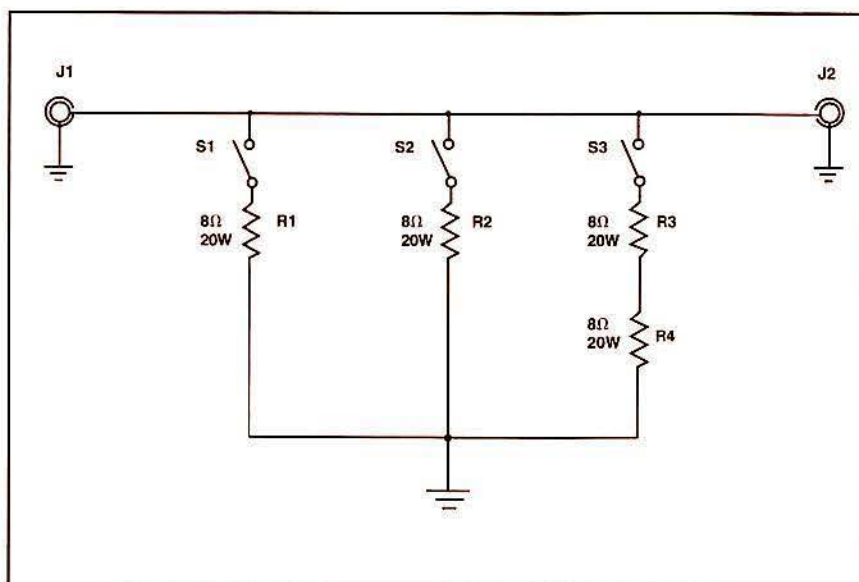


Figure 1. All that is needed to build the test box are four 20W 8Ω resistors (available at Radio Shack, part #271-120, for \$1.49 each), three single-pole single-throw (SPST) switches, two BNC female coaxial connectors and an enclosure.



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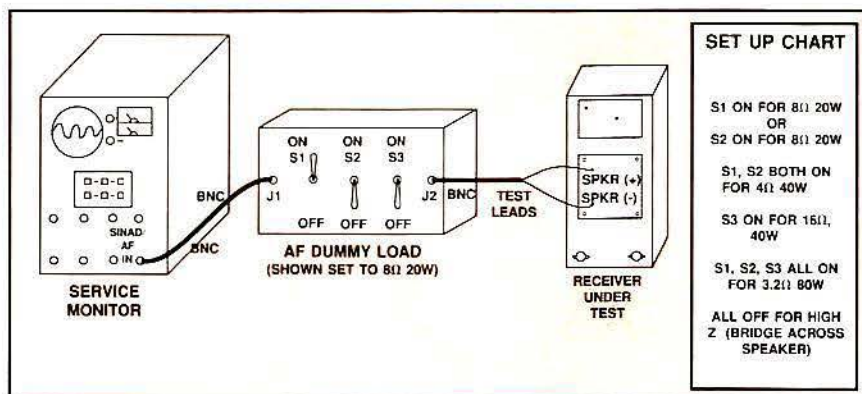


Figure 2. Select the proper speaker impedance from the chart, turn on the receiver, apply rated audio to the test box (observing the limits shown), and begin troubleshooting. This example shows the typical operation of the audio dummy load.

below its licensed frequency:

$$173,396,250\text{Hz} - 1,000\text{Hz} = 173,395,250\text{Hz}$$

Adjustment of this transmitter would be necessary according to FCC rules to bring it into its licensed tolerance.

#### Audio dummy load protects hearing

One particularly useful function that most service monitors lack is an audio fre-

quency (AF) dummy load.

An AF load is really helpful when tuning receivers and checking SINAD. It also helps to keep peace in the shop because your fellow technicians do not want to listen to a loud 1,000Hz test tone for any length of time.

An audio dummy load can be built for little cost to cover the following ranges:

- ▶ 20W at 8Ω.
- ▶ 40W at 4Ω.

- ▶ 40W at 16Ω.
- ▶ 80W at 3.2Ω.

All that is needed are four 20W 8Ω resistors (available at Radio Shack, part #271-120, for \$1.49 each), three single-pole single-throw (SPST) switches, two BNC female coaxial connectors and an enclosure. A schematic of the test box is shown in Figure 1 on page 24.

Connect the test box jack (J1) to the service monitor's SINAD or scope input or the input normally used to measure audio signals. Connect the other end of the test box (J2) to the audio output of the receiver under test, with the speaker disconnected.

Select the proper speaker impedance from the chart included with Figure 2 to the left. Turn on the receiver, apply rated audio to the test box (observing the limits in Figure 2) and begin troubleshooting.

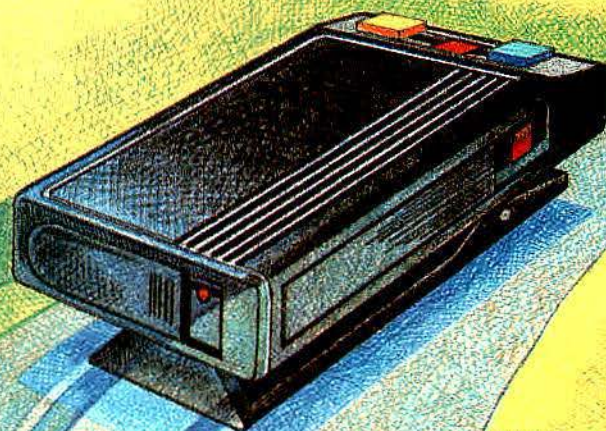
Figure 2 shows the typical operation of the audio dummy load.

I have built several of the test boxes for our shop's vehicles and for the shop. Connected with BNC patch cables, the test boxes can sure protect your cars (and your fellow technicians' ears) from stress.



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# Automated data-gathering supports quality management

*Part 2—Turnkey, automated data-capture systems help service facilities and communications providers to gather and analyze information for quality management. Performance reports help sales efforts, too.*

By Donald E. Koehler

Part 1 in this series (January 1994 issue) explained that the idea behind quality management (QM) is to gather data to use in making decisions.

As it applies to servicing radio communications systems, QM includes gathering data on reactive, preventive, performance-based and cost-based maintenance procedures. Analyzing the data uncovers hidden costs in doing business; reduces radio and system downtime with the use of performance-based maintenance; provides your sales force with a powerful tool; and al-

lows better resource allocation based on demonstrated need.

By now, you may have read one or more of the books listed in the first installment. If not, at least you have given some thought to the types of data you deal with regularly.

The next step is to look at some of the factors and specific data used for analysis, data capture methods for small businesses and how to use outside consultants and experts when necessary.

One of the ideas stressed by QM experts is the notion of "the important few vs. the unimportant many." It is impossible to track and to analyze every bit of data your business can generate.

The trick is to sort out the few really key pieces of data and then to determine how to capture them in a database.

Take time to consider what your operation is about. Is your company a value-added retailer, a service business or a

communications provider? Is systems integration and management the primary function?

## Pageco example

Consider, for example, a fictitious start-up private carrier paging service provider called "Pageco." This company sells and leases various pager models and provides a wide-area paging service.

Much effort went into a market analysis and survey. The pager brands and models were chosen, and people were hired to staff a small maintenance facility and the sales and business offices. The initial venture, bidding for and receiving the contract to provide equipment and service to a large nearby hospital, was successful.

Beginning at this point, Pageco will be directly and materially affected by the data it captures and the method used to capture information.

Koehler is a technical writer; technical resource researcher; and computer, communications and database specialist for Hartec Management Consultants, Anchorage, AK.

PAGECO Pager Database	
Customer Information	
Pager Model Number:	Serial Number:
Bar Code:	Cust. Acct. #
Comments:	
Battery Information	
Last Replacement Date:	Current Replacement Date
Manufacture #:	Manufacture #:
Technical Information	
Last Date:	Current Date:
Signal to Noise:	Signal to Noise:
Freq. Tolerance:	Freq. Tolerance:
Tone Tolerance:	Tone Tolerance:

Figure 1. This is a sample computerized database screen for a fictional company, Pageco.

PAGECO Pager Database	
Customer Information	
Pager Model Number: <u>2363R45</u>	Serial Number: <u>3734563</u>
Bar Code: <u>18283545487309328</u>	Cust. Acct. #: <u>99506</u>
Comments: <u>Mr. Jones — CEO of Imprco Inc.</u>	
Battery Information	
Last Replacement Date: <u>931125</u>	Current Replacement Date: <u>940220</u>
Manufacture #: <u>Everlife</u>	Manufacture #: <u>Neverdie</u>
Technical Information	
Last Date: <u>931125</u>	Current Date: <u>940220</u>
Signal to Noise: <u>13.5</u>	Signal to Noise: <u>13.6</u>
Freq. Tolerance: <u>138.000</u>	Freq. Tolerance: <u>135.003</u>
Tone Tolerance: <u>67.00/206.5</u>	Tone Tolerance: <u>67.0/206.5</u>

Figure 2. Information printed in color reflects the kinds of data that may be kept in Pageco's database.



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If your service requires a state-of-the-art dispatch console, Orbakom's TDM-150 is the solution. TDM-150 is a custom system, so we'll configure it the way you need it — up to 120 channels or more and 120 positions. TDM-150 uses time-

division multiplex (TDM) digital audio processing and complete microprocessor control. Operation is simple and menu-driven. Reliability is ensured through surge protection, self-healing diagnostics, and battery backup. Eight levels of multi-channel radio and telephone patch may be run simultaneously, and an internal paging signalling encoder generates any sequence you'll ever need. Plus the best two-year console warranty in the business.



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**ORBAKOM  
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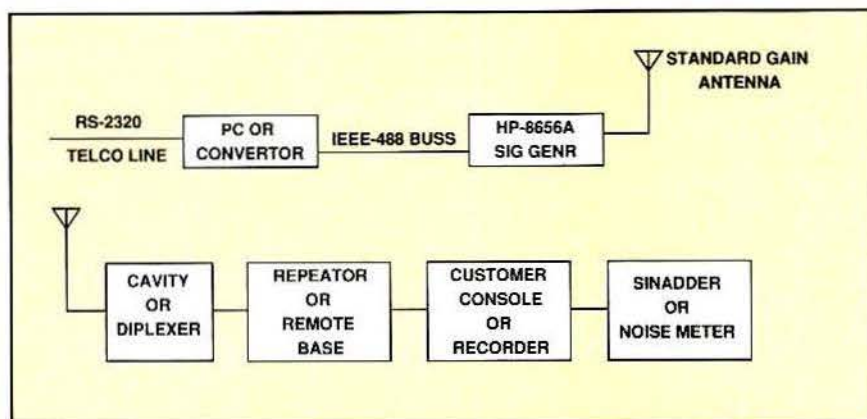


Figure 3. This automated test setup generates a signal of known strength and feeds it into a known antenna. It provides a reproducible test signal for the system under test.

Figure 1 on page 28 is a sample computerized database screen. Figure 2 on page 28 shows the kinds of data that may be kept in Pageco's database. Beyond the apparent choices of equipment type and serial number are two types of information worth a detailed look.

The first information block is marked *bar code*. Pageco has decided to automate its data-gathering as much as possible. It makes sense to use bar coding because

good-quality bar code readers sell for low prices and come with a large choice of supporting software.

With a bar code reader, a single stroke of the laser gun, or *wand*, connected to the computer retrieves and displays all the stored data about the equipment and its user without the risk of entry error.

The second information block, marked *comments*, can be used to store a variety of information from the client's name and

credit status to an indication of whether the unit was lost or stolen.

### Snapshots

Using multiple databases and sharing data makes it possible to view *snapshots* of work depth and validity.

For example, battery use and replacement data can be merged with airtime billing information to check battery performance.

Is the less-expensive battery really cheaper to use? The performance record gives the answer.

Does a certain pager brand or model perform better, last longer and require less maintenance? Again, the database records information to answer the question.

Pager use vs. model type is revealed by merging airtime account billing with the maintenance database. When the local cement plant put out a request for bid (RFB), Pageco was prepared to make a better and smarter bid backed up with performance data.

Other data may be tracked, too. The Pageco example may stimulate your thoughts about other uses for automated data entry in your current operations.

Bar coding can help to track technician

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ASP KAV-850  
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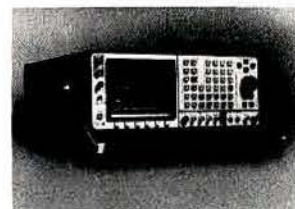
IFR COM 120A  
Eagle return loss bridge  
Auburn P-20 probe  
Easyspan  
Bird 43N  
Bird load  
Astron DC supply  
EasyCom - PC

### CELLULAR FULL SERVICE

IFR COM 120A  
Bird 43N  
Helper MB-800  
ASP KAV-850  
B & K 810A  
Auburn P-20 probe  
Astron DC supply

### FACTORY ATE

IFR 1600  
EasyCom software  
TMAC developers kit



### CELLULAR CARRIERS ANALOG

IFR 1600 for AMPS  
Eagle return loss bridge  
Autocell  
Easyspan  
Bird 43N w/ slugs & case  
Bird load



### CELLULAR CARRIERS DIGITAL AMPS

IFR 1600 CSA for Digital AMPS or Dual Mode  
Eagle return loss bridge  
Autocell  
Easyspan  
Bird 43N w/ slugs & case  
Bird load

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IFR AN930  
Eagle return loss bridge  
Easyspan



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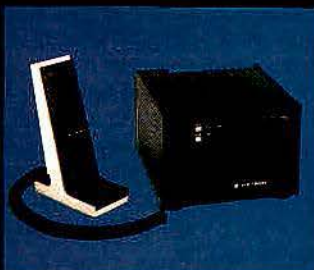
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3A > 32A

33

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SL-11R-RA



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productivity. Assign your technician bar codes. Bar code the test equipment, too, to see how often it is used.

Parts from stock and installation kits can be assigned bar codes to make it faster and easier to capture data about how they are used and the time it takes to use them.

Bar coding is not the complete answer to data-gathering, but it is a good example of a way to reduce data entry time and errors and an easy way to automate part of a maintenance facility.

#### Systems approach

Many maintenance facilities do not take a *systems approach* to maintenance.

Figure 3 on page 30 is an automated test setup. This setup generates a signal of known strength and feeds it into a known antenna. It provides a reproducible test signal for the system under test.

Such a setup might be used in a business with several repeaters or remote base stations that are co-located or positioned within line of sight of each other. It might be used to check base station performance. The point is to use a verifiable, repeatable standard for systems testing.

Figure 4 above shows an example of several weeks' test results. The chart shows

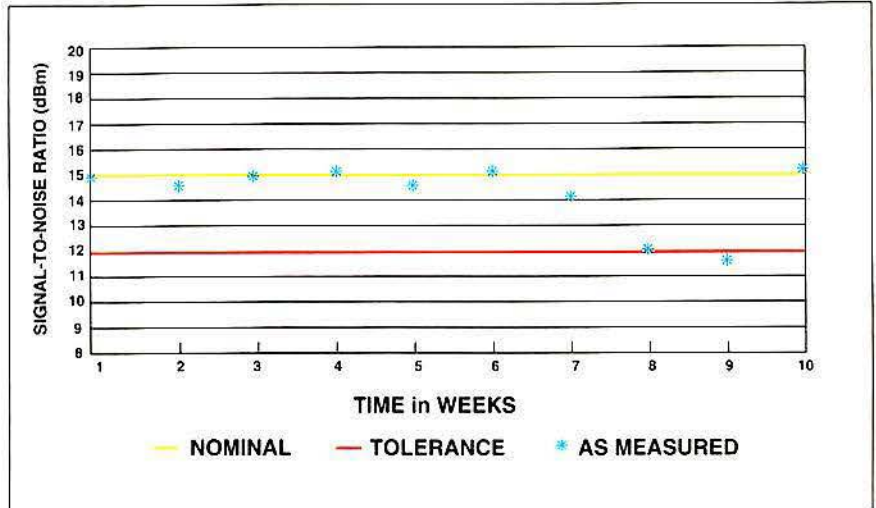


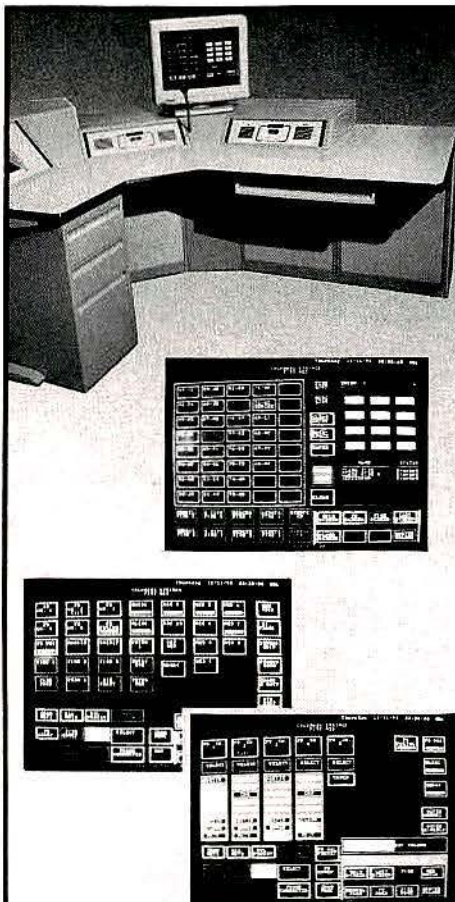
Figure 4. This chart of several weeks' results from tests using the setup in Figure 3 compares actual receiver performance with nominal and minimum performance. It shows that the system began to experience a loss of performance, which was restored when a technician performed maintenance.

that the system began to experience a loss of performance, which was restored when a technician performed maintenance.

Nominal values and tolerances are determined by checking performance right after a system tuneup or installation. These

data can be useful for bid compliance documentation and interference complaint resolution.

If this system were a long distance from the service center or if downtime were difficult to arrange, maintenance might be



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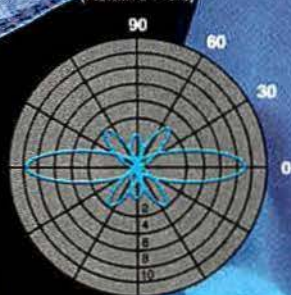
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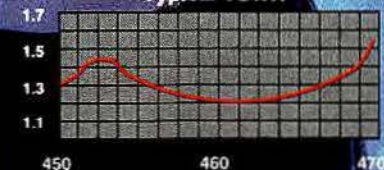
Radiation Pattern  
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VSWR

Typical VSWR



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undertaken only when poor performance is obvious. Even then, maintenance might be delayed until the technician had to visit the site for another, unrelated reason.

Performance data can be used for long-term maintenance planning, future equipment and service bids and sales efforts. After all, demonstrated performance is a strong selling point.

All this talk about automated systems for data capture may have some readers

shaking their heads, thinking: "No can do; I'm no computer whiz."

If you are not a computer whiz, the last thing you should do is to spend a lot of time becoming a programmer. Instead, spend time deciding what kind of data to accumulate and what reports or results of the data analysis would be useful.

Then, buy a turnkey automated data capture system. Good business practice dictates that the bid go to the programmer

or service company with a demonstrated ability to understand your needs and to integrate a system to match them.

You already may have a computer-based billing system or office. With the addition of the proper software and perhaps some hardware, your existing computer equipment may form the basis for an automated data-gathering and analysis system.

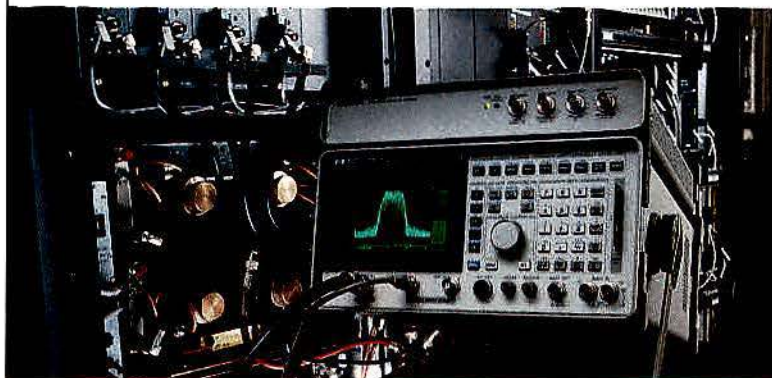
Insist that the vendor name several customers you can call to learn how successfully the vendor has satisfied their needs.

Ask the vendor these questions:

► How will the system and software support future growth?

► How will your employees receive training and technical support?

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It actually speaks back to you with hard-copy results in formats you defined so you don't waste time writing it down. It displays set-up diagrams and tuning diagrams and checks manufacturer's specs for you. And it directs the base station during testing so you and your laptop computer are free to do other things. In short, tests virtually run themselves so you have more time for troubleshooting and optimizing.

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\*In Canada call 1-800-387-3867, Dept. 464

## *Choosing a vendor for an integrated data gathering and analysis system is an investment in the future.*

► Is technical support available by telephone?

► How much will additional training cost?

► Is the system software able to work with future computers?

Using an outside consultant or value-added retailer can be a wise choice. When an integrated system has been provided by one vendor, that vendor is responsible for resolving problems. Using multiple vendors raises the possibility that each vendor may blame another for a problem, making a resolution difficult to achieve.

### Summary

Various kinds of data, data-gathering methods and automation may be useful to service facilities and communications providers. The choice of which "few" data items are valuable to you depends on your operation.

Using a testing standard, tracking performance and developing a performance-based maintenance strategy offers obvious advantages.

Choosing a vendor for an integrated data gathering and analysis system is an investment in the future.

The next installment in this series explains some of the hidden costs that can be revealed by using a quality management program.





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**K**

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- ♥ LEDs: scramble mode light, call light, & transmit light



**Q**

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## Smallest Full-Duplex or Half-Duplex Speech Inversion Scrambler

- ♥ Single code inversion scrambler
- ♥ Motorola VPA compatible
- ♥ Simultaneously scrambles & descrambles
- ♥ Crystal controlled for high stability
- ♥ Very good recovered audio quality and speaker recognition
- ♥ Single input lead takes a ground to change between scramble and clear
- ♥ Available with flying leads

**10 VPU-7**

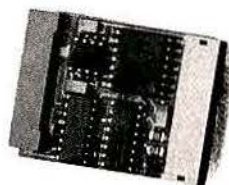


## Smallest Simplex Inversion Scrambler

- ♥ Ultra-thin simplex inversion scrambler
- ♥ Single code scrambler
- ♥ Anti-aliasing input filter
- ♥ Crystal controlled for high stability
- ♥ Excellent recovered Audio Quality
- ♥ Microminiature quick disconnect connector with color coded leads for simplified installation and removal. Available with optional flying leads.

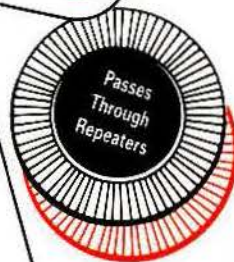


**J VPU-2**



## Subminiature Tunable Voice Inversion Scrambler

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- ♥ Anti-aliasing input filter
- ♥ Six-pole tracking output filter
- ♥ Simplex operation
- ♥ Excellent recovered audio quality
- ♥ Microminiature quick disconnect connector with color coded leads for simplified installation and removal. Available with optional flying leads.



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# Servicing pagers: Build an 'IFFER'

*Part 2—The IF section from a transistor radio makes an ideal accessory for the test fixture designed for Bravo pagers. Whether you use a shielded room or not, the accessory improves alignment results.*

By David Ludvigson

One day, a heavy brass object arrived at JJ Sounds, where I work.

The company owner, J.H. Kim, looked completely baffled. "How do you use?" he asked.

I took a look and chuckled. It was the Motorola RTL-1005 test fixture: nearly \$500 worth of enclosed antenna planes and shielding with a cantilevered set of springs for test probes. To the uninitiated, it must closely resemble the Wouff Hong!\* (See Photo 1 and Figure 1 below.)

Following the directions for modifying the test fixture for use with Bravo series

\*The Wouff Hong, from an amateur radio legend, is a fictitious device said to be used for punishing radio operators who misbehave.

Ludvigson is a technician in Houston.

## Pager servicing series

"Servicing Pagers: Build a Shielded Room," January 1994.

"Servicing Pagers: Build An 'IFFER'," February 1994.

Back issues printed within the past two years can be ordered for \$5 each, postpaid. Call customer service at 800-441-0294. Issues printed more than two years ago and individual article photocopies are unavailable from the publisher.

paggers requires a few minutes of work, and then a bit more time is required to get the assembly to drop the test probes across test point M1 and ground on a Bravo. (See Photo 2 on page 38.) Unfortunately, after finally adjusting everything, problems just seemed to follow.

First, the pager has to be put into the monitor mode. It seems that these units

spend a good deal of their time turned off until they receive the appropriate preamble paging code. Turning the Bravo into a full-time receiver involves turning the pager off and depressing both the black and gray buttons simultaneously while turning the pager back on to the beep mode.

A steady 3.2kHz tone follows. You now have two seconds to release both push-buttons; quickly depress the gray button and release it. The word PAGING with an optional suffix will appear. Now you can troubleshoot the pager reliably.

While the window displays the word PAGING, insert the Bravo (with the back cover removed) into the test fixture. Close the clamp to connect the decoupling network to M1 and ground.

According to Motorola, alignment of the Bravo can be achieved with an ac millivoltmeter when subjected to an "on-frequency" signal. As I adjusted the output level of the Ramsey Com 3, there were times when the millivoltmeter responded

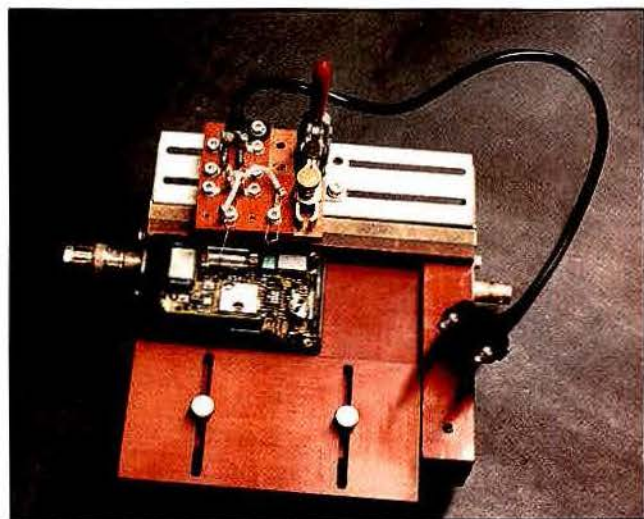


Photo 1. The Motorola RTL-1005 is nearly \$500 worth of enclosed antenna planes and shielding with a cantilevered set of springs for test probes.

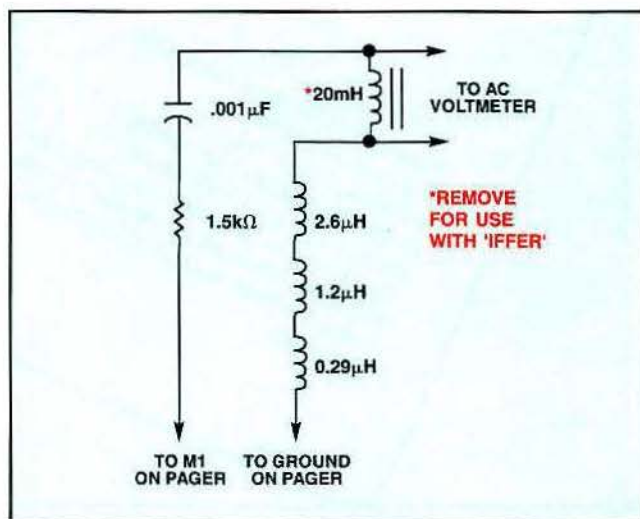


Figure 1. To use the IFFER with the RTL-1005 test fixture, remove the 20mH choke across the output. Otherwise, the inductor swamps the IFFER's input.



# Good Things & Small Packages



Yes, it's true! Good things DO come in small packages...especially at RELM Communications. RELM's new line of radios include some of the most compact mobile and portable radios available. These radios feature a wide variety of power and feature combinations to meet virtually every application. And, best of all, these small packages carry small prices, too!

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#### SL Series Mobiles: (above)

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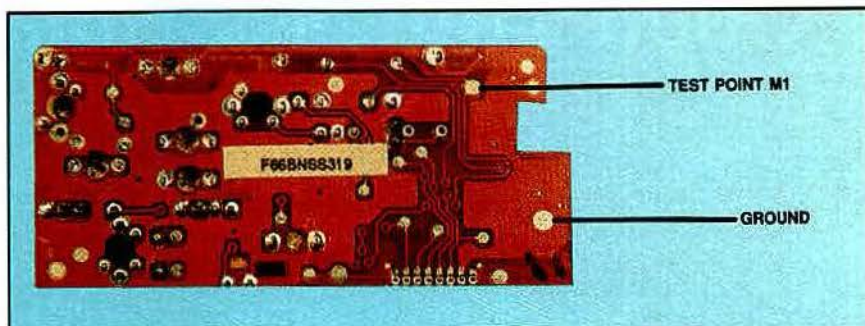


Photo 2. Adjust the RTL-1005 test fixture's probes across test point M1 and ground on a Bravo pager.

smoothly, and other times when it jumped all over the place.

We had not built the shielded room yet, and I was certain that signals from nearby paging transmitters were interfering with the pager test measurements. (See Part 1 in the January issue for information about building the do-it-yourself shielded room.)

Test point M1 is at the input of a 455kHz intermediate frequency (IF) amplifier, and it is isolated by a ceramic filter. To be able to differentiate between the signal from the signal generator and signals from the on-frequency paging transmitters, I use an external 455kHz IF strip followed by an

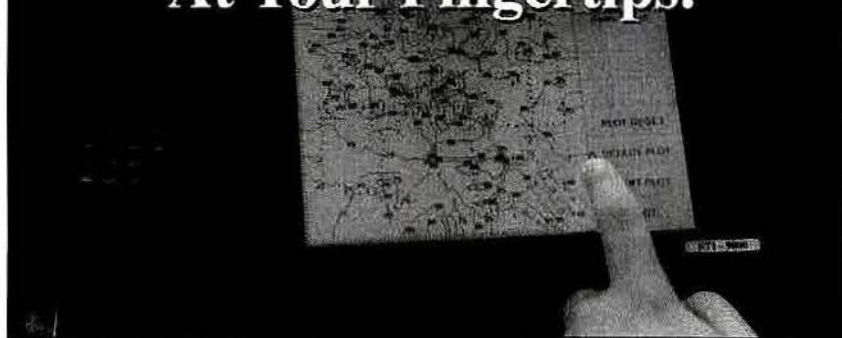
audio detector and audio frequency (AF) power amplifier. By connecting an oscilloscope across the loudspeaker, I can see and hear when the pager is properly tuned.

To find a suitable IF strip, I experimented with a transistor AM radio. These radios are plentiful, and the part with a 455kHz IF amplifier, an audio detector and an AF amplifier forms about 4/5 of the radio.

Standard transistor radios have a converter that feeds two IF stages at 455kHz. Coupling from M1 on the pager through the radiation test fixture to a point in the IF of an external radio provides several

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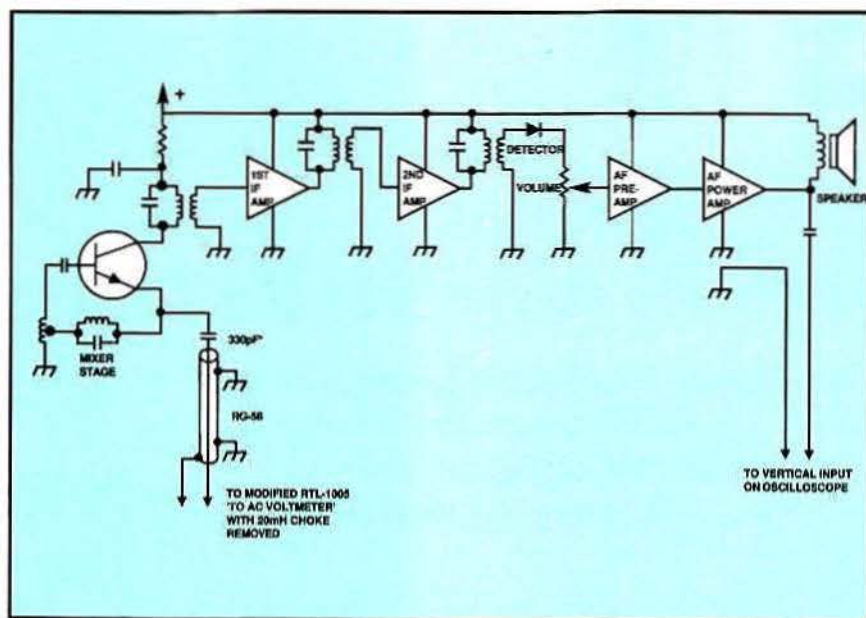


Figure 2. The IFFER is an AM transistor radio's intermediate frequency (IF) strip. A 330pF capacitor (marked with an asterisk) is tied to the primary side of the AM radio's converter, and the radio is tuned to any unused frequency.

advantages.

First, the AM radio continues to operate as an AM radio.

Second, the signal at M1 is sufficiently strong to be transported easily over three feet of RG-58 coaxial cable and translated

at the external IF strip. (See Figure 2 to the left.)

With the IFFER in place, the 20mH choke across the output of the RTL-1005 is removed. This inductor swamps the input to the IFFER and just gets in the way. A 330pF capacitor is tied to the primary side of the converter in the AM radio, and the radio is tuned to any unused frequency in the broadcast band.

With the IFFER, pager alignment is vastly improved. Standard Sinadder techniques of using a 3.5kHz-deviated 1kHz tone on the selected frequency are sufficient. Unless you have a shielded room such as the one described in Part 1 of this series, on-frequency "rattling" by nearby paging transmitters will upset any alignment attempt. There is no uncertainty as to the cause of erratic meter readings when using the IFFER; you can both see and hear the interference.

#### Acknowledgement

I would like to thank J.H. Kim, owner of JJ Sounds, South Houston, TX, and co-workers Raymond, Tim and Pete, for their help with this project.



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# Circuit mods improve satellite receiver system

*Applying 'jamming' and 'anti-jamming' theory and 'wanted' and 'unwanted' signal concepts to public safety radio satellite receiver-comparator wide-area coverage systems helps to improve quality and reliability.*

By Carl Ebinger

Wide-area radio systems sometimes rely on a remote receiver and repeater network to improve communications.

To put it simply, *satellite receivers* are connected to a *voter* that electronically indicates the relative quality of received signals. A *comparator* selects the best signal and routes it to the operator.

The Dade County, FL, emergency medical service (EMS) uses 17 satellite receivers in three districts to cover the county's 2,000 square miles.

Each district has a repeater, and repeaters are selected automatically by the master comparator.

Despite the use of 17 receivers and three repeaters, communications on the county's 10 medical communications (MEDCOM) radio channels were poor and unreliable.

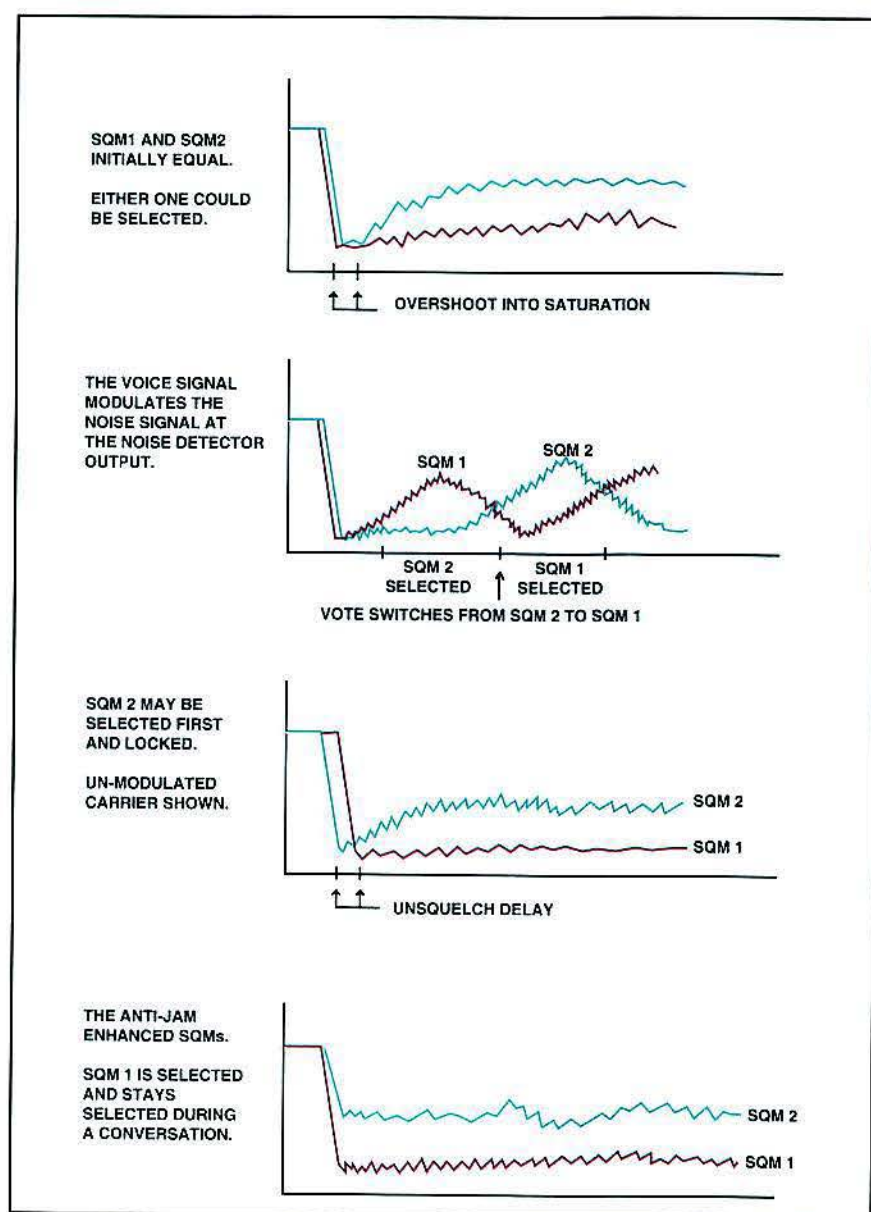
The fire department requested help in improving the rescue vehicle-to-hospital radio transmission quality and reliability.

The following information describes how and why my analytical approach and circuit problem-solving design ideas were applied to resolve the comparator's signal-selection difficulties, and how they were related to the poor quality and reliability of communications on the MEDCOM channels.

## Signal comparator

The Motorola Spectra Tac model T1786A comparator makes erratic signal selection errors having to do with phase relationships among model TRN6091A *signal quality module* (SQM) audio inputs.

Ebinger is a radio technician with Dade County, FL. His experience includes transistor circuit designing. For 13 years, he worked as an engineering technician assigned to military and NASA projects at research and development laboratories in Boston and Los Angeles.



Representative graphs of the Motorola signal quality module model TBN6091B noise detector outputs show the effect of the original circuitry and of the modified circuitry.



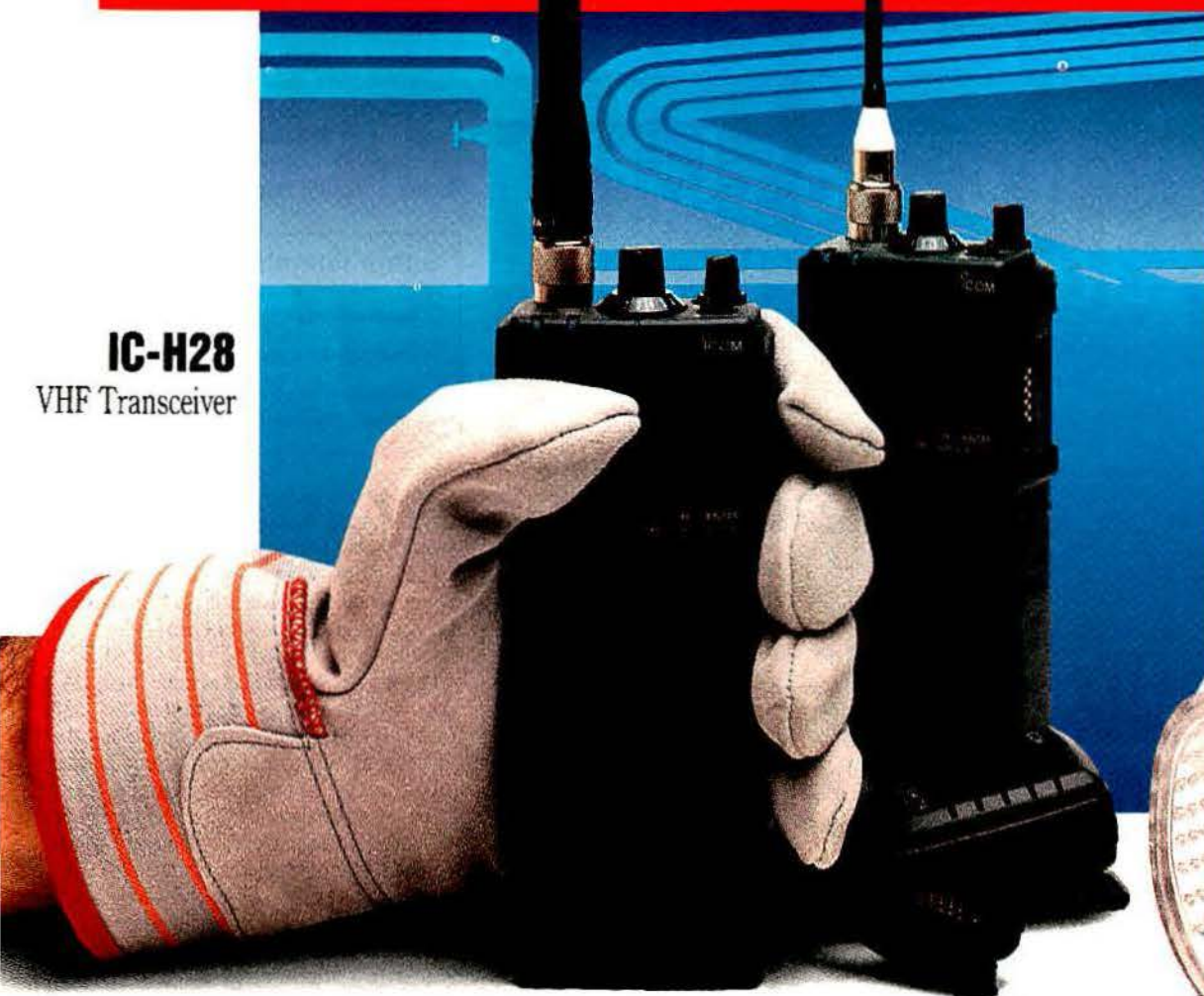
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# ICOM



Moreover, the *audio signal* can significantly degrade the comparator's signal selection accuracy, stability and reliability because of the SQM voice circuit selectivity characteristics.

Because the defect is in the system design, manufacturers' consultants who conducted an evaluation of 10 channels submitted a report stating that no major defects in the setup of the system were found, nor were there any problems with the

preventive maintenance.

Only a few minor level-adjustment errors were found in some of the channels, and the calibration was accurate for most of the channels. The less-than-satisfactory performance of all 10 channels at the time of the evaluation, and for many prior years, could not be explained.

#### In-house evaluation

My first step was to examine and ana-

lyze the SQM noise and voice circuitry signal waveform interactions and to evaluate and diagnose the causes of the perplexing signal selection faults that were uncovered when the comparator was operated in the unlocked mode.

The 10 MEDCOM channels require 200 SQMs, 20 per channel. Seventeen SQMs are in three subcomparator groups, and three SQMs are in the master comparator.

The solution was to invent a simple, inexpensive, operationally superior circuit design based on passive components that eliminate illogical voting and vote-switching in and out of noisy signals, signal chopping and reception that cuts out during a mobile transmission.

#### Some jamming sources

- ☐ External—intentional enemy action.
- ☐ External—unintentional friendly users.
- ☐ Internal—unwanted signal-mixing in a receiver, producing unreadable output.

This circuit pioneers the use of the time-domain mode to apply a dynamic, bandwidth-narrowing attenuation to the voice signal circuit to improve the isolation between voice and noise signals greatly so the voice signal cannot interfere with noise detection.

Quite often, paramedic radio transmissions to the dispatcher, field units and hospital emergency room could not be understood because reception cut in and out or because of high background noise or static bursts that interrupted the message.

Typically, paramedics often were asked to repeat their messages, especially critical information such as the medication names and doses and the estimated time of arrival. If the paramedics and others were unable to communicate on the channel selected, one of them would request that the dispatcher assign them a new channel.

Watching the equipment operate during such episodes, I noticed a correlation in the unlocked master comparator's unpredictable, random switching between noisy and quiet sites *during the conversation*. This switching was not as noticeable with an *unmodulated carrier*.

Measurements made during mobile transmissions revealed that the comparator made illogical signal selection choices whether in the locked or unlocked mode. In addition, the initial vote selection was inconsistent—the comparator did not always choose the signal with the lowest noise, even when there was a steady, non-fading signal from a fixed-tower antenna.

Monitoring the comparator and measur-



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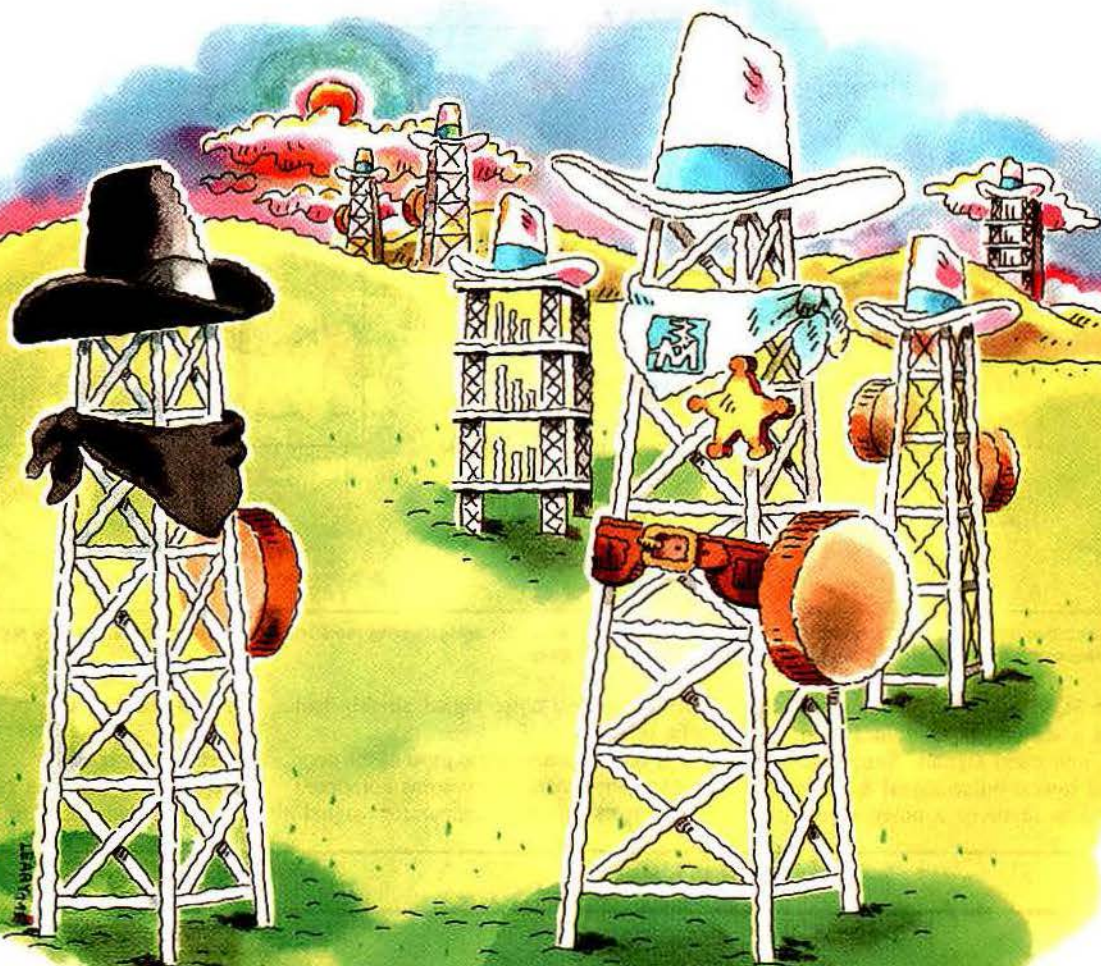
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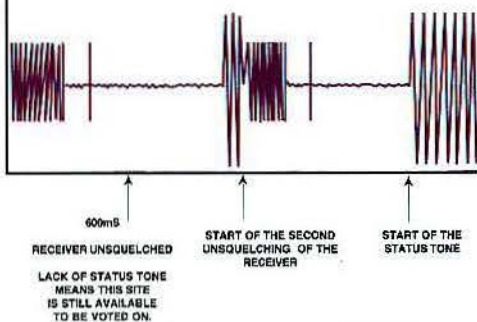
## BEFORE MODIFICATION

## AFTER THE MODIFICATIONS

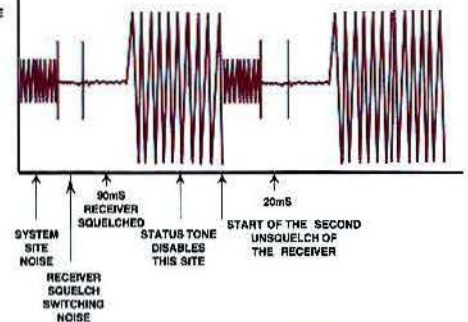
INPUT TO THE MASTER COMPARATOR SQM

IF THE RECEIVER REPEATEDLY UNSQUELCHES AND RE-SQUELCHES (AS HAPPENS WITH A WEAK SIGNAL), THE COMPARATOR MAY SELECT THIS SITE DUE TO THE LONG QUIET PERIODS.

SECONDARY LINE DRIVER A  
JU-6  
INSTALLED



SECONDARY LINE DRIVER  
JU-5  
INSTALLED



Representative graphs of the secondary line driver outputs before and after anti-jamming modifications are installed show how repeated squelching and unsquelching during weak-signal reception affect receiver voting.

ing the SQM signal processing circuits revealed a seemingly random selection of noisy, unwanted signals. Sometimes, the wanted lowest-noise signal was forcibly rejected in favor of a noisy signal even

after the lowest-noise signal already had been selected.

My conclusion was that most of the poor system performance symptoms correlated with errors in the comparator signal-

selection-and-rejection process.

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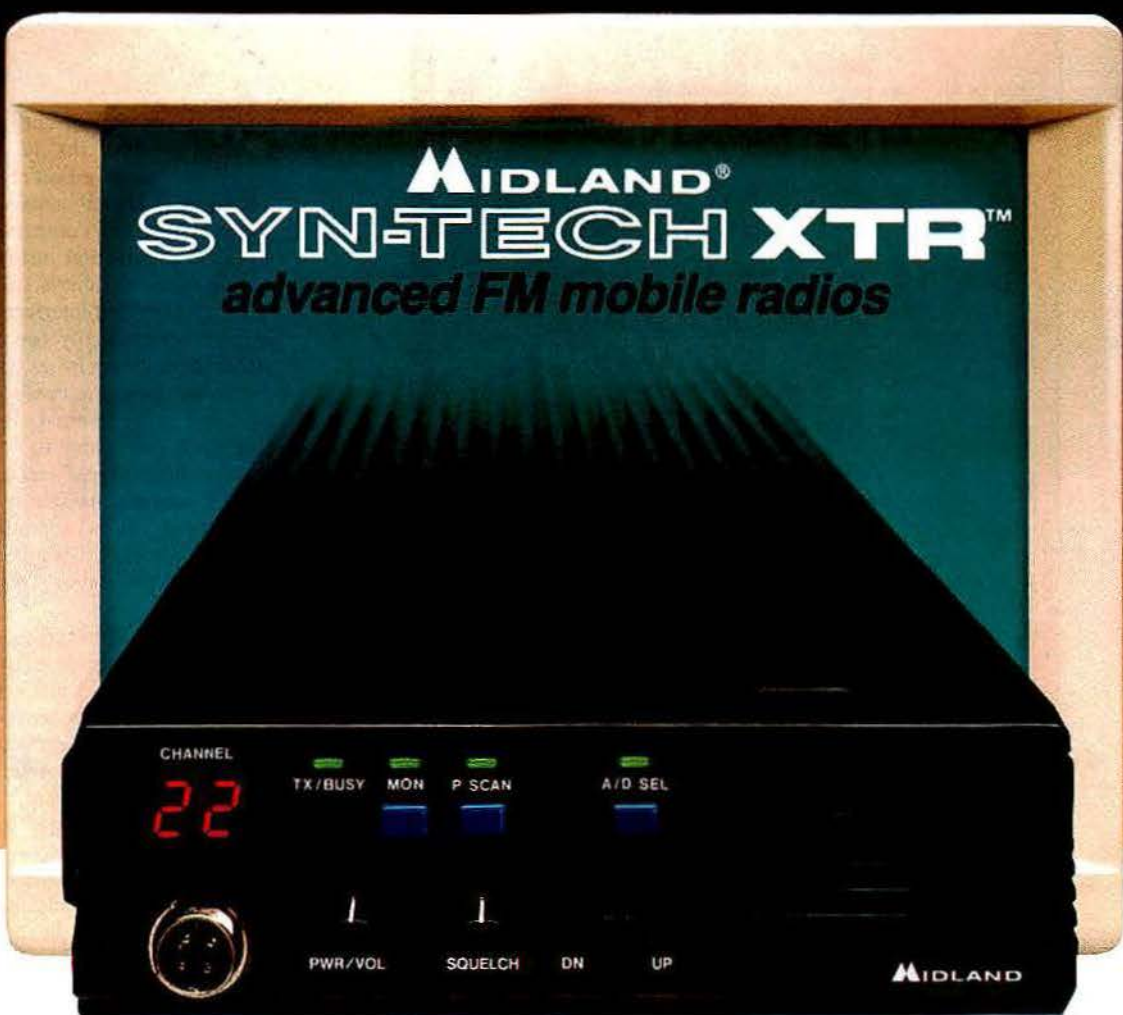
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nications and for an anti-jam, command destruct receiver for the NASA Saturn rocket led me to consider the possibility that internal signal-jamming might be responsible for the comparator's improper signal selections and instability.

Any radio receiver is susceptible to external and internal interference and can be jammed intentionally (as by an enemy), unintentionally (as by an open mic or by a distant co-channel or nearby adjacent channel user) or by internal signal-mixing interference (self-jamming).

After input signal measurements ruled out all potential outside reasons why the comparator might scramble the signal-selection process, I began to think of the problem in the context of internal signal-jamming.

For analytical purposes, the entire 17-site satellite receiver network, interconnecting microwave links, three subcomparators and one master comparator were considered as one integrated radio receiver having one audio output and a space-diversity antenna system.

If some shortcoming or limitation in one of the comparator plug-in modules could be verified and identified, the problem might be resolved by designing some kind of jamming protection into the deficient circuit.

Efforts focused on pinpointing the faults that seemed to lie in the SQM circuitry to determine why the comparator was not consistently accurate in the unlocked mode and to effectively select, hold, track, or lock onto the lowest-noise signal available.

SQM measurements revealed a signal interaction that could make the comparator vulnerable to self-induced jamming due to the following causes:

1. Poor noise-detector noise-discrimination capability.
2. Poor voice circuit passband selectivity.
3. Excessively fast noise-detector response.
4. Sensitivity to audio phase relationships at the SQM inputs.
5. The lock option mode selected.
6. Marginal noise-detector sensitivity.

### Noisy signal selection

The comparator does not always select the lowest-noise signal available and cannot be left to operate unattended in the unlocked mode because it may *switch-vote* in and out of noisy signal sites during a conversation.

When the comparator is set to the *lock-for-the-duration-of-the-conversation* mode, there is a significant probability that the initial vote will select a noisy site, and then the selection remains with that site.



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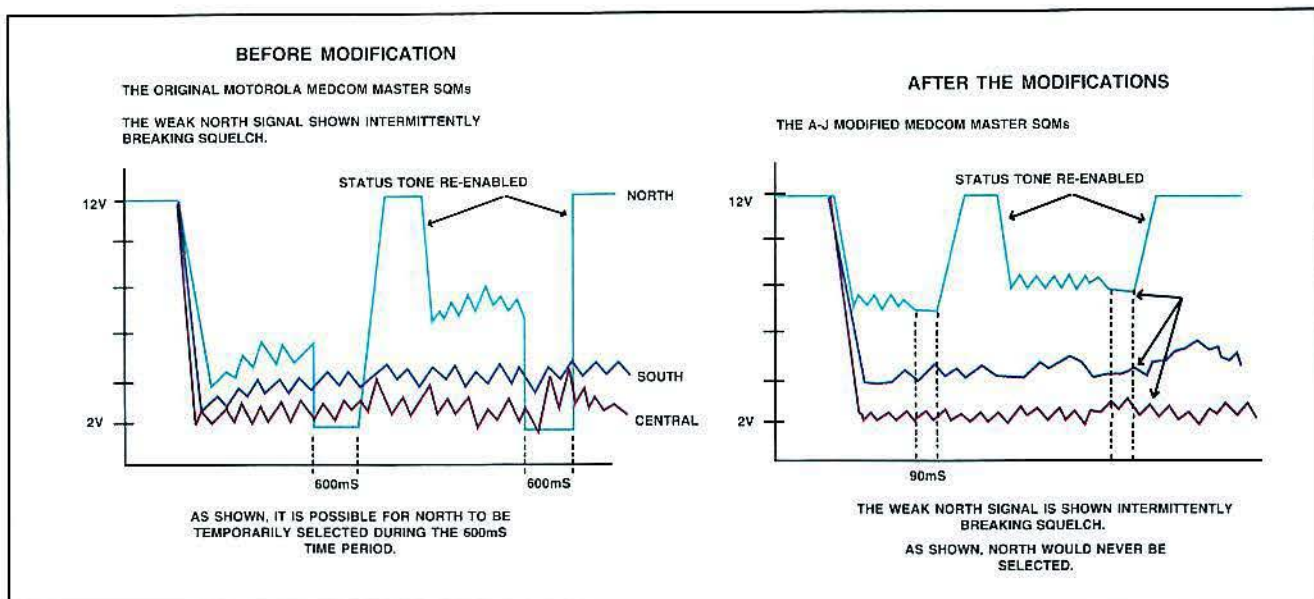
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Representative graphs of signal quality module pin 18 outputs before and after modification show how the anti-jamming circuitry eliminates the selection of a weak signal that intermittently breaks the squelch.

If the comparator is set to the *unlocked* mode, it may change its selection to a noisy site whenever a weak signal breaks in and out of squelch. This unfortunate selection

is made because each time a receiver squelch closes, the status tone is delayed 550 milliseconds before being re-enabled. With this lengthy delay, multiple squelch

cycles with short bursts of receiver noise may *average out* as though the noisy signal were the lowest-noise signal.

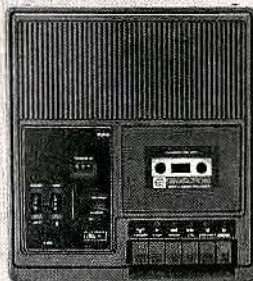
SQM waveform measurements showed



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that the noise-detector output contained some of the voice signal because of insufficient lowpass filtering in the voice-processing circuit and insufficient highpass filtering in the noise circuit.

Vote-switching induced by modulation on the selected signal occurs when voice-signal components enter the noise-detector circuit, allowing a portion of the voice signal to be processed falsely as noise.

This problem would not be as pro-

nounced if the audio signals at all SQM inputs were nearly in phase. The worst case is with a 180° phase difference. Then, the audio signal adds or subtracts from the noise signal with the maximum detrimental effect by generating false high-noise and low-noise outputs that force a false signal selection switch or a voting error.

For example, assume that the lowest-noise signal with a voice peak is applied to SQM 1 input and that this signal is com-

pared to a noisier SQM 2 input where the voice signal is 180° out of phase at maximum negative voltage.

At this moment, SQM 2 might be selected because the voice signal has mixed with the noise signal and *subtracts* from it, resulting in a false low-noise output. At SQM 1, the voice signal mixes with the noise signal and *adds* to it, generating a false high-noise output that is rejected by the comparator.

Voice components randomly take command of the noise-detector and interfere with its noise-processing function whenever they are large enough to overwhelm the noise signal and the 2dB *locking factor*. This phenomenon frequently forces the comparator to re-select to another SQM.

A symptom of this problem is that the voted site seems to bounce around during a conversation in the unlocked mode. Even the 2dB locking factor cannot control the

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MR1

*The cause of the quality  
degradation resulting  
from this involuntary  
random switching of the  
selected vote can be  
interpreted as signal  
jamming.*

problem. This random scrambling of the signal selection has a serious jamming effect on the entire system.

The cause of the quality degradation resulting from this involuntary random switching of the selected vote can be interpreted as *signal jamming*. It results from the *wanted* audio signal interfering with the *selected* signal by amplitude-modulating the associated noise-detector, thus forcing the comparator to select some *unwanted* signal before re-selecting to the *wanted* signal.

Masking the problem by operating the system in the *lock-for-the-duration-of-the-conversation* mode is not the solution because the initial comparator vote may not select the lowest-noise signal available and, once having made an incorrect initial selection, it cannot re-select to a lower-noise signal.

Signal recognition and acquisition based on the true noise levels at the SQM inputs is unreliable and unrepeatable under these



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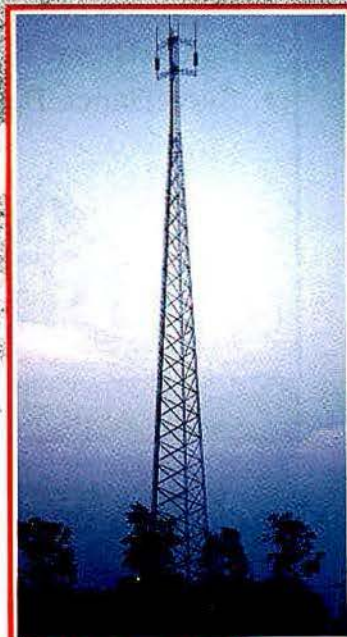
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circumstances. The satellite receiver network is randomly jammed, and the comparator signal-selection process is disrupted by the *wanted* voice signal that was *supposed* to be captured and recovered.

#### Noise-detector response

Another factor influences the comparator signal-selection process.

Whenever the receiver unscrambles, the SQM noise-detector's excessively fast re-

sponse forces the detector into a saturated, non-linear state.

Even though this condition is transitory, it can result in many SQMs *momentarily* presenting a *false lowest-noise-possible state* to the comparator, and any one of them could be selected randomly as a vote, with the possibility that the lowest-noise signal may not be selected.

The master comparator's stability in staying with the actual lowest-noise

signal was improved greatly by removing jumper JU-6 from the sub-comparators' *secondary line driver modules'* printed circuit boards and installing jumper JU-5 instead. This change shortens the status tone enable delay from 550 milliseconds to 90 milliseconds to reduce the SQM noise-detector false low-noise inputs when weak signals are received.

#### Circuit development

Next came exploratory circuit development with active and passive design modifications to the SQM circuits.

The comparator signal selection accuracy and repeatability needed to be improved by eliminating the SQM noise detector overshoot and the voice signal interference. The goal was to obtain the best possible accuracy in unconditionally selecting and tracking as a vote the *wanted* lowest-noise signal available and to reject as a vote all other *unwanted* noisier signals.

The comparator was set in the unlocked mode by removing the *command module* jumper JU-11. Removing this jumper causes a loss of the lock during telemetry transmissions. To restore lock during the telemetry function while keeping the comparator unlocked during other periods, install a diode with its cathode connected to pin 13 and its anode connected to pin 7 of the command module.

With original SQM circuitry's limitations having been defined, an effort was made to push the state of the art in comparator signal selection accuracy and stability by narrowing the voice-signal pass-band to reduce the noise-detector interference, and to make the improvement inexpensively and with minimum component changes.

A two-transistor active circuit proved quite successful but too complicated to install.

#### Time-domain circuit

Eventually, one exploratory SQM circuit yielded a significant 33dB increase in the suppression of the voice signal at the noise-detector input. The circuit uses a unique scheme, operating in the time-domain mode, rather than in the frequency-domain mode, to introduce a dynamic, automatic bandwidth reduction to the voice-signal circuit that effectively attenuates the voice-signal spectrum.

Narrowing the voice-circuit bandwidth further isolates noise from the voice signal. This narrowing inhibits voice interference to the noise-detector by not allowing the detector to respond to voice signals, and it enables interference-free noise detection. The purpose of this modification

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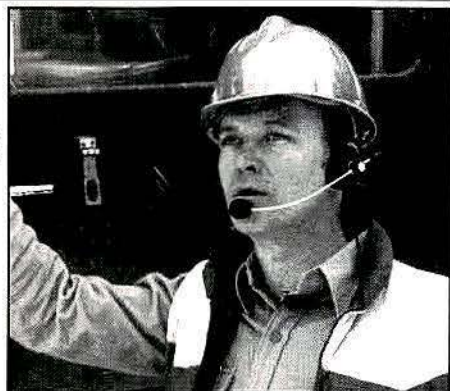
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**Table 1—The Motorola signal quality module noise detector characteristics measurements.**

**Noise detector dynamic voice rejection:**

(1) Standard (SP) version .....	0dB
(2) Anti-jamming modified version .....	-33dB

**Noise detector noise gain:**

(1) Standard (SP) version .....	+27dB
(2) Anti-jamming modified version .....	+37dB

**Noise detector 1kHz CW tone suppression:**

(1) Standard (SP) version .....	-22dB
(2) Anti-jamming modified version .....	-22dB

is to inject additional stability into the signal selection-and-holding process.

To increase the signal selection accuracy and resolution, the SQM noise circuit was modified to increase its gain by 10dB.

The research and development effort eliminated the jamming effects of comparator voice-induced vote-switching and stopped the noise-detector from overshooting into saturation. With the modifications, the comparator operates correctly in the

unlocked mode, and the signal selections are smooth, accurate, stable and reliable.

Tightening the SQM's voice-signal selectivity has resulted in a technologically superior, jam-resistant comparator signal-selection process, a process that is the heart of a satellite receiver system and that determines the system performance characteristics.

With the changes, the comparator now achieves a much higher degree of accuracy

in acquiring, holding and tracking the *wanted* lowest-noise signal available than previously was obtainable. This fine performance on the part of the comparator is enhanced by its increased ability to reject all other noisier *unwanted* signals.

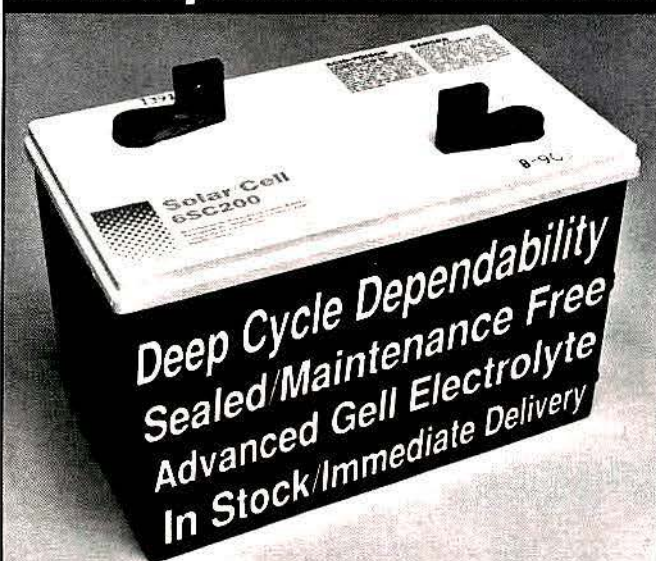
Since its operational deployment in 1989, this engineering design improvement has greatly enhanced the clarity, reliability, quality assurance and efficiency of communications between the rescue vehicle paramedics and hospital emergency rooms.

Upgrading the satellite receiver comparator performance was a quality improvement accomplished solely by correcting errors that were being made in selecting of the audio signal recovered from the four comparators in a MEDCOM channel.

The project was accomplished by working on the job and at home. It required eight months to complete, and the modifications were made for a material cost of *less than 25 cents per SQM*.

In 1990, the innovation was put in use to upgrade the quality of the fire department tactical radio channel, a system with a combination of 27 General Electric receivers and Motorola SQMs.

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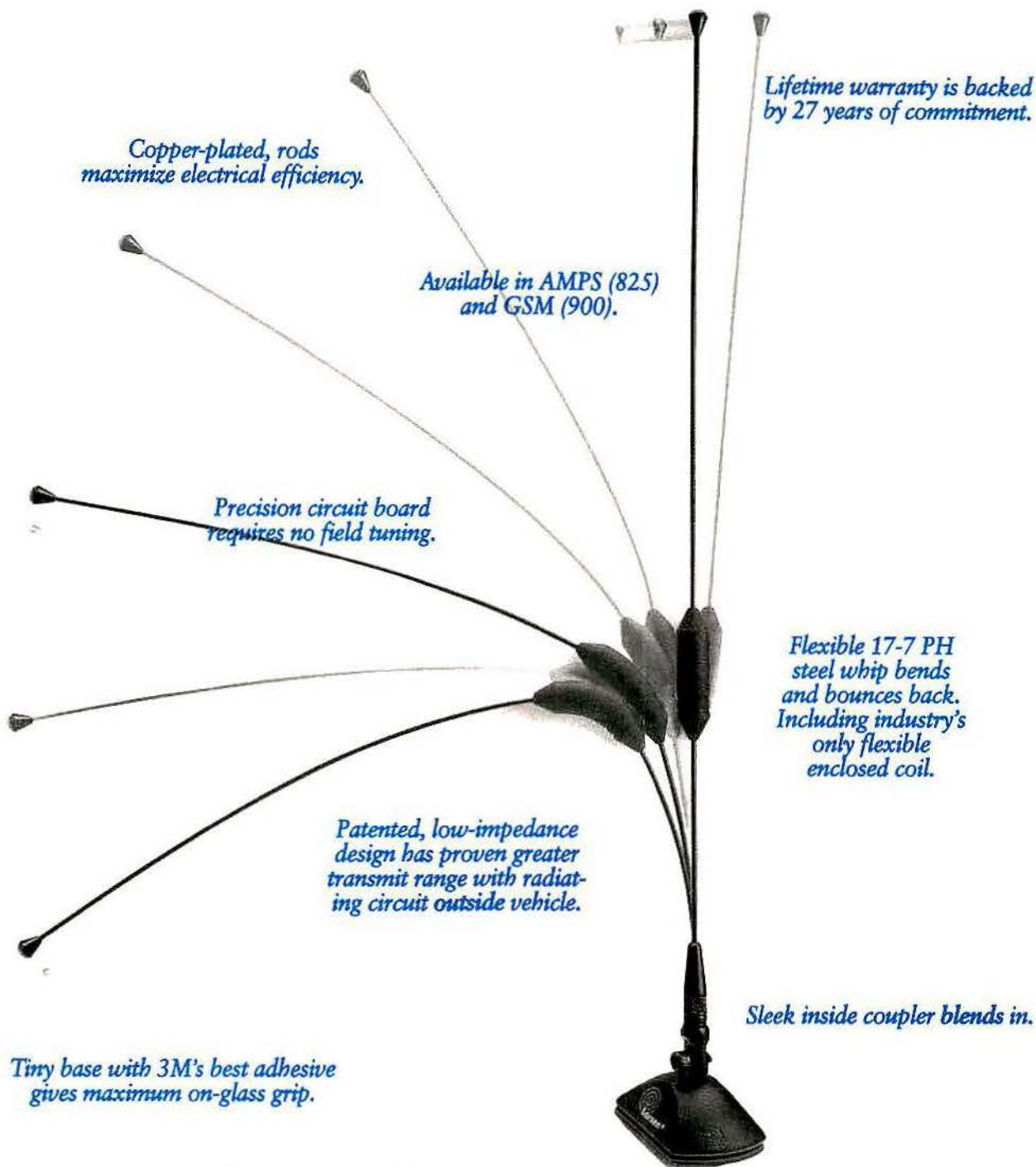
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## Technically speaking

between any two ports. This second formula gives the *theoretical* insertion loss; the actual insertion loss is higher because of imperfections.

For the three-port (two-way) combiner-splitter shown in Figure 2, the resistance value (for each resistor) is 16.7Ω. The loss between any two ports is 6.02dB.

Figure 3 on page 8 shows the design of a resistive four-port (three-way) combiner-splitter that might be used in the setup shown in Figure 1B. Calculations for the resistance value and loss figures are shown in the figure.

Advantages of resistive combiner-splitter networks include their simplicity of design and ease of construction in the shop. Another advantage of resistive networks is that they operate at frequencies as low as dc. They even can be checked for accuracy with a dc voltage.

For example, the three-way combiner in Figure 3 can be checked by terminating three of the ports with a 50Ω termination and then applying 3Vdc across the open port. Exactly 1Vdc should be measured at each of the terminated ports, representing a 9.5dB loss.

### Disadvantages

A disadvantage of resistive combiner-splitter networks is that, at higher frequencies, the networks may become reactive because of stray inductance and capacitance. This reactance can upset the impedance match and balance enough to invalidate test results. Although resistive networks can be manufactured to perform well at higher frequencies, manufacturers do not use the ordinary, garden-variety resistors that generally are found in two-way radio shops!

Another disadvantage is that resistive



**Photo 1:** This is a four-way, transformer-type combiner-splitter network. If all ports are not needed for a particular setup, the unused ports can be terminated in 50Ω. Photo courtesy of Mini-Circuits, Brooklyn, NY.

action between the signal generators or other devices connected to the ports.

### Transformer networks

Transformer types of combiner-splitter networks offer several advantages over the resistive combiner-splitter networks. The insertion loss is lower for the transformer networks.

For example, a two-way resistive network, as shown in Figure 2, would have an insertion loss of 6dB. The theoretical insertion loss of a *transformer-type* network would be half as much, or 3dB. The theoretical insertion loss for a transformer combiner-splitter network equals  $10 \log (N - 1)$ , although the actual insertion loss is slightly more.

Remember, combiner-splitters are passive networks, and as such they cannot amplify. Consider an eight-way (nine-port) splitter (transformer type). The minimum insertion loss is:

$$\begin{aligned} 10 \log (N - 1) &= 10 \log (9 - 1) \\ &= 10 \log (8) \\ &= 10(0.903) \\ &= 9.03 \text{ dB} \end{aligned}$$

The actual insertion loss is somewhat higher. One catalog advertised an eight-way divider as having a maximum insertion loss at any output port of no more than 2dB. What I suppose that really means is that the insertion loss does not exceed the *theoretical* insertion loss by more than 2dB. Imagine how surprised you might be if you bought this device, expecting no more than a 2dB insertion loss, only to find that the loss exceeds 10dB!

To illustrate the point, let's be silly for a moment and add up the power levels at each of the eight output ports with 1W of signal input power at the input port (assuming a 2dB insertion loss). Now, 2dB below 1W is 0.63W. If we multiply this

*Advantages of resistive combiner-splitter networks include their simplicity of design and ease of construction in the shop.*

combiner-splitter networks provide little isolation between signal generators or other devices connected to the ports. The isolation equals the loss between ports (6dB for the two-way network and 9.5dB for the three-way network). Without sufficient isolation, there might be some inter-



power level by eight output ports, we have:  $8 \times 0.63\text{W} = 5.04\text{W}$  of total output power from the divider. That is very good, considering that the input signal is only 1W! Somehow, the total power output of this device is five times the input power, quite a major achievement! Total output power can *never* exceed the input power to a device, whether it is passive or active. Considering that no device is 100% efficient, the output power always is *less* than the input power.

#### Isolation

The big advantage of transformer combiner-splitter networks is the isolation that they provide between ports. Typical isolation figures range from 20dB to 30dB and

*The big advantage of transformer combiner-splitter networks is the isolation that they provide between ports.*

vary depending upon frequency. A typical transformer-type combiner-splitter network is shown in Photo 1 on page 58.

Transformer combiner-splitter networks can be checked for insertion loss using the setup shown in Figure 4A on page 60. First, connect the RF voltmeter directly to the signal generator and set the signal generator output to produce 0dBm on the RF voltmeter. (The signal generator level meter also should indicate 0dBm.)

Then, using the setup of Figure 4A, measure the output level from the combiner-splitter on the RF voltmeter. It should read slightly less than -4.8dBm (-5dBm or so). This reading is the insertion loss of the combiner-splitter.

Note the signal generator level, and then increase the generator output to produce once again a 0dBm reading on the RF voltmeter. Read the new generator level. The difference between the first generator level and the second should equal the insertion loss of the combiner-splitter and provide a confirmation of the first measurement.

The isolation provided between ports on the combiner-splitter is an important characteristic. Isolation provided by the transformer combiner-splitter network depends in large measure on the quality of the impedance match at the S (sum) port. To check a transformer combiner-splitter

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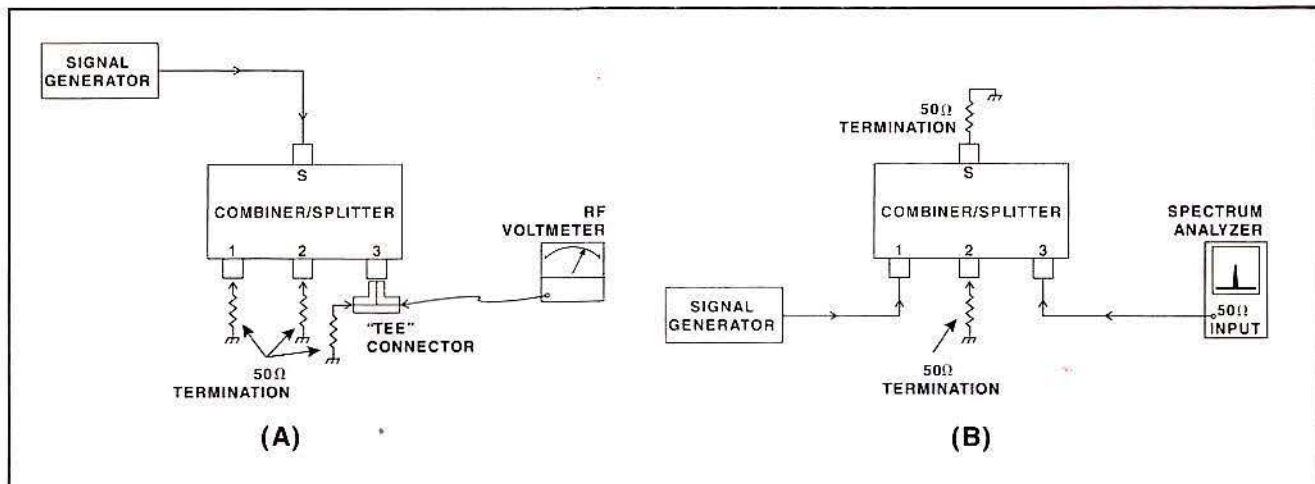


Figure 4. The setup at (A) is used to measure the insertion loss of a transformer-type combiner-splitter network. See text for procedure. The

setup at (B) is used to check the isolation figure for a transformer-type combiner-splitter network. See text for explanation.

network's isolation, use the following procedure:

With the equipment configured as shown in Figure 4B above right, first connect the signal generator directly to the spectrum analyzer and set it to produce a 0dBm reference level on the analyzer. Then, connect the analyzer and generator to the combiner-splitter as shown. The signal level is determined from the spectrum analyzer display. If the display is  $-25\text{dBm}$ , then the isolation of the combiner-splitter is 25dB between ports 1 and 3.

### 50Ω terminations

Notice that the 50Ω terminations are connected to the unused ports of the combiner-splitter in the test procedures. This is common practice. Unused ports should be properly terminated. Terminations are

available with proper fittings, such as BNC and N connectors, for only a few dollars.

Because the impedance match at the common, or S, port is so important in maintaining proper isolation between the other ports, it is advisable to use a matching pad between the signal generator and the combiner-splitter ports. This practice is shown in Figures 1A and 1B. The extra padding serves as a stabilizing influence and further improves the reliability of the test procedure. It is always a good idea to pad the signal generator outputs to maintain a good impedance match. It is a simple matter to take the attenuation of the pad into account in determining the test procedure results.

This information should help you to purchase the proper combiner-splitter for your specific application. If you can afford

only one combiner-splitter, buy one with at least one more port than you think you will need. You can always terminate the unused port. The only drawback is slightly higher insertion loss. For example, the theoretical insertion loss of a three-way (four-port) network is 4.8dB, whereas the four-way (five-port) network's theoretical loss is 6dB.

Combiner-splitter networks of the type described here are available from several sources. Two such sources are Pasternack Enterprises (Coaxial Products Division), P.O. Box 16759, Irvine, CA 92713, tel. 714-261-1920; and Mini-Circuits, P.O. Box 350166, Brooklyn, NY 11235-0003, tel. 718-934-4500.



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## Visiplex paging system improves security operations

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## Codecomm opens headquarters in Atlanta

Codecomm has opened its southeastern regional headquarters in Atlanta to house its corporate, retail, dispatch and service operations. Codecomm focuses exclusively on alphanumeric display paging. "Alphanumeric is by far the biggest growth segment of the paging market," said Michael A. Goeler, Codecomm's vice president and general manager. Although it now represents only 4% of the total paging market, in the next five years, alphanumeric paging is projected to grow to 25%.

In addition to personal messaging, Codecomm will offer financial, traffic, headline news and weather reports, as well as other messaging services.

In the next four years, Codecomm plans to expand into other southeastern and mid-Atlantic cities. Codecomm's parent company is Celpage, San Juan, Puerto Rico.

## Stabilant wins listing in Motorola book, catalog

Stabilant 22A, a contact enhancer made by D.W. Electrochemicals, Richmond Hill, Ontario, is available from Motorola's Worldwide Systems & Aftermarket Products Division, telephone 800-422-4210. The 15ml service kit is Motorola Part No. 800-80369E78 and is listed in the "Buyers Source Book" and the "Tools & Shop Supplies Catalog." A small amount of the contact enhancer applied to an electromechanical contact substantially improves the contact's reliability.

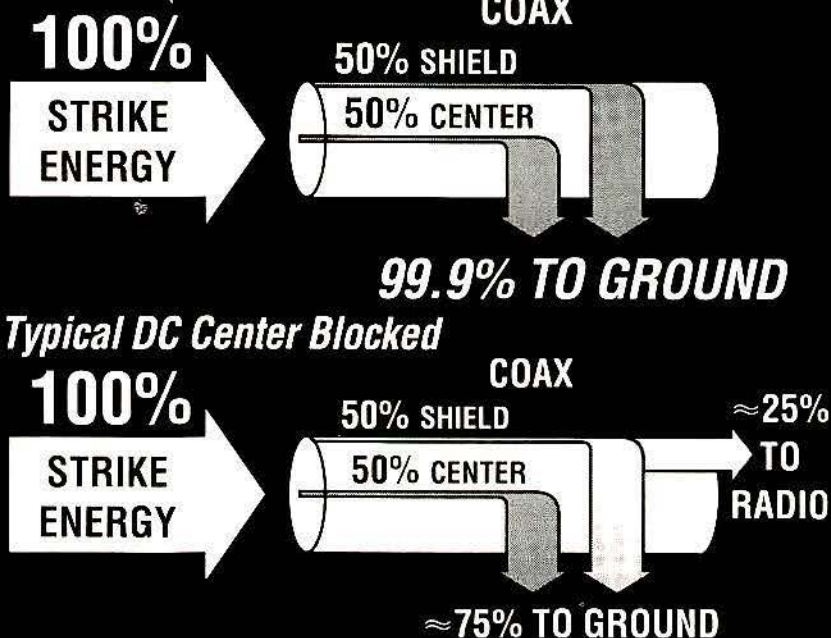
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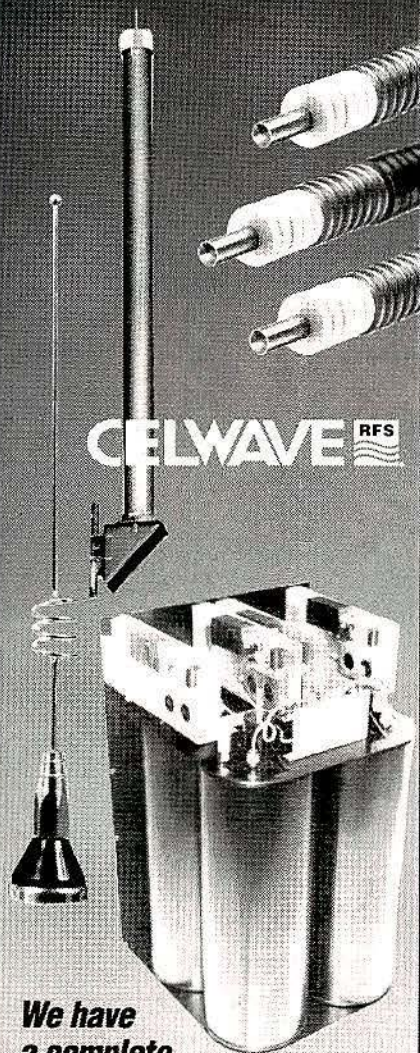
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## News

### Pagetrac study shows paging transition from business to personal users

The results of a study by Economic and Management Consultants International (EMCI) show that the paging industry is undergoing a major transition from business to personal users. More than 50% of new paging customers are primarily personal users. To target the consumer market, carriers are emphasizing retail distribution, but problems such as churn rates, competitive retail pricing and consumer education are proving to be challenges associated with retail distribution.

Despite the problems, carriers expect significant sales from retail distribution. Large carriers estimate about 15% of sales will come from retail and project the number to increase to about 35% in the next two years.

"Pagetrac: Consumer Trends in Paging," analyzes the consumer paging market from carrier, manufacturer and user profile perspectives. EMCI randomly surveyed 3,000 households in the top metropolitan markets to determine trends in paging user profiles, behavior and preferences.

Respondents were asked where they obtained their pagers: 48% obtained them through their workplace; 20% from paging company salesmen; 15% through retail stores; and 11% obtained their pagers from visiting a paging company's office.

Twenty-six percent of the respondents said they received two messages per day; 35% received 3-5 messages; 22% received 6-10 messages; and 17% received more than 11 messages per day.

### NABER says 'integrity' is key to Pioneer's Preference

In Reply Comments filed with the FCC, the National Association for Business and Educational Radio (NABER), Alexandria, VA, emphasized the importance of requiring that an awardee of a Pioneer's Preference actually construct the system it proposed when seeking the preference.

NABER President E.B. "Jay" Kitchen said that NABER's Association for Private Carrier Paging (APCP) was concerned that the "integrity of the program would be marred should the commission allow systems to be constructed that are mere dupli-

cates of the work being performed by others and not the innovative proposals for which they were rewarded the spectrum."

Included in the comments was APCP's belief that construction extensions should be granted only in the most extreme circumstances. Kitchen stressed that the association was not asking the FCC to discourage further innovation by the awardee but to encourage the awardee to exceed its proposal in the actual construction, assuming the technology is still within the limits of the original award.

### Rockwell, Omnipoint to integrate PCS Technologies

Rockwell International, Newport Beach, CA, and Omnipoint, Colorado Springs, CO, signed a memorandum of understanding to integrate Omnipoint's wireless spread-spectrum technology with Rockwell's semiconductor and manufacturing expertise to provide low-cost, high-performance personal communications services (PCS) subsystems.

The companies are pursuing the joint integration and delivery of both components and subsystems ranging from chip

sets and handsets to base stations.

Omnipoint was awarded a tentative Pioneer's Preference by the FCC in October 1992 for a PCS operating license in the New York City region. The award was based on Omnipoint's innovative technology and the system's capability to share with OFS users in the 1,850MHz-1,990MHz bands, as well as the company's status of being the first to introduce spread-spectrum PCS handsets operating at 1,850MHz-1,990MHz.

### Sprint Cellular chooses Motorola to provide CDPD equipment

Sprint Cellular, Chicago, has signed a letter of intent with Motorola's Wireless Data Group, Schaumburg, IL, to equip Sprint's cellular network with cellular digital packet data (CDPD) equipment necessary to conduct a wireless data transmission trial early in 1994. In the trial, an oil and gas company will control and monitor its remote gas wellheads through Sprint's cellular network channels.

Sprint Cellular recently formed a national cellular data team to oversee the company's efforts in the area of cellular data transmission. "The team's primary mission is to deliver circuit switched data services today and packet switched services in the near future," said George Hutton IV, executive vice president of operations for Sprint Cellular.





## Bits and pieces

By Robert H. Schwaninger Jr.

The "doin's" at the FCC include a host of revealing activities. What they reveal might be subject to interpretation, and reasonable bureaucrats may differ, but here are a few tidbits, dateline Washington, D.C.

### FOB gains another weapon

On Nov. 23, 1993, the FCC authorized its Field Operations Bureau (FOB) to issue subpoenas in matters regarding unlicensed transmitter operation and unauthorized radio equipment sales. What prompted this action is unclear. One has to wonder whether enforcement actions have been hampered in the past when field agents were required to wait for the commissioners to approve using subpoenas to demand documents or the appearance of witnesses. Note that the delegation of authority is to *issue subpoenas*, not to allow *searches or seizures*.

The FOB still would require a warrant to search certain premises. It is unclear

whether a warrant would be required to search a licensed radio facility—probably not. A warrant probably would be re-

*The one question the commission has yet to answer about frequency coordinators is, "Who do they work for and, thus, who should pay them?"*

quired before the government could seize equipment.

### Gadfly Update

The FCC has issued a Memorandum Opinion and Order to deny, dismiss, reject and otherwise discourage any further motions, petitions, letters or requests from

Merrill T. See of *The Rattler* fame.\* Mr. See has sought reconsideration of the FCC's frequency coordination system for years, organizing two-way dealers and filing enough paper before the commission to demand a bulk rate from his local office supply house.

One has to admire Mr. See's tenacity, especially in light of his progress. He has consistently sought to overturn the frequency coordination system by whatever means were available, arguing that a monopolized market is not in the public interest. Thus far, the FCC has rejected all of his arguments.

The one question the commission has yet to answer about frequency coordina-

\**The Rattler*, a newspaper published monthly by Merrill T. See in 1987, carried news and opinions that expressed See's viewpoints about monopoly frequency coordinators.

Schwaninger, MRT's regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington, DC.

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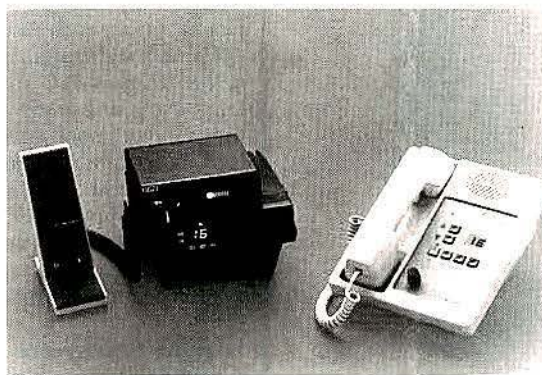
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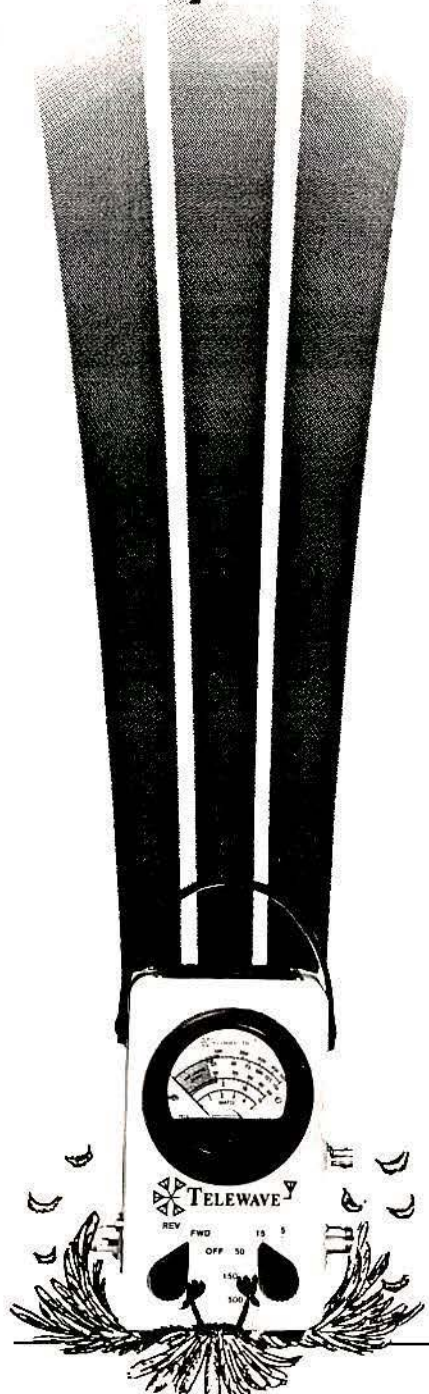


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## Regulating technology

tors is, "Who do they work for and, thus, who should pay them?" As long as that question remains unanswered, it is doubtful that Mr. See and his associates will disappear.

### They've got your number

If you have ever been ripped off by someone who has gained access to your private branch exchange (PBX), payphone, database or cellular phone, then the opportunity for you to vent has arrived. The FCC's *Notice of Proposed Rulemaking*, CC Docket No. 93-292, seeks comments on how to reduce or eliminate the theft of telephone services.

These crimes often pit carrier and customer against one another as they attempt to shift the burden from one to the other. The carrier wants to be paid for the services, and the customer wants to be excused for unauthorized uses. While the squabbling and investigations continue, access thieves are making off with literally hundreds of millions of dollars in service each year.

Carriers and customers should work together to improve precautions against these thefts and to devote their resources to solutions rather than litigation. In the past, the victims were the biggest losers as they debated in a series of expensive proceedings before the FCC and in the courts. It's time to focus on the criminals and to find ways to put them in court, instead of carriers and customers.

### Harmful interference

The FCC has issued an unpublished Notice of Apparent Liability against Greens Communications, Pottsville, PA, for willful and repeated creation of harmful interference to private co-channel operators. The notice reads that Greens was observed transmitting unauthorized paging traffic that unnecessarily tied up the channel and created harmful interference.

This decision follows the FCC's action taken earlier this year against a West Virginia operator. In that action, the FCC also alleged that the operator created harmful interference to competitors in the operation of a private carrier paging facility. It appears that the old days of frontier justice in the operation of private carrier paging

(PCP) facilities might be drawing to a close. Greens' \$16,800 fine is certainly a telling sign.

### Chairman's choice

Newly confirmed FCC Chairman Reed Hundt is assembling a new staff to assist him during his tenure, including General Counsel William E. Kennard. The selection and confirmation of Chairman Hundt was a long time coming, and the delay drew some quiet criticism around D.C. The industry's impatience might have been

more extreme had it not been for the able stewardship of Commissioner James Quello, who served as acting chairman.

Commissioner Quello's long experience was a definite plus during the transition. However, one should not overlook Commissioner Quello's ace-in-the-hole, Brian Fontes. If you want to write a letter to Congress

or President Clinton to suggest a nomination, Brian Fontes has my vote for any slot open on the commission. And, as you might gather, I'm a hard one to please.

### News from the burn ward

Finally, the FCC released a study titled "RF Current Reduction Provided by Work Gloves at AM Radio Broadcast Frequencies" (FCC Reference No. FCC/OET RTA-93-01). The commission studied whether work gloves would reduce the danger to technicians who, remarkably, might decide to grab a hot AM tower. Using actual humans (perhaps to avoid animal rights activists' outcries), the study found that wearing heavy leather work gloves helped.

The study was appropriately released during the Christmas season. Rumor has it that one of the test subjects in the study found work as a well-lit Santa on someone's lawn, brightening the night in the best Yuletide tradition. He was holding an aviation study showing that his height, painting and lighting met federal requirements.

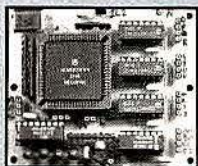




## Reader's choice

Of all the new products and services in the June 1993 issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, here is your opportunity to acquire more information on them: Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

### Computer interface retrofits Tandy programmable scanning receivers



The HB-232 scanner and computer interface retrofits to Tandy/Realistic PRO-2004, PRO-2005 and PRO-2006 programmable VHF and UHF scanning receivers.

The interface offers two-way communications and control of the receiver by a 640k IBM compatible with a 9,600-baud serial port. The HB-232, from **Commtronics Engineering**, allows local, remote and automated control of all the scanner's keyboard functions.

Circle (500) on Fast Fact Card

### Communications network operates in 902MHz-928MHz range

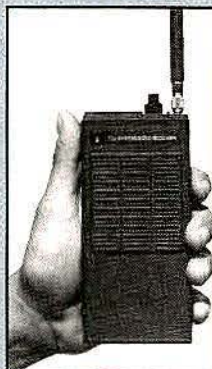
The VoiceNet 2000 wireless digital voice communications network from **Repro** operates in the 902MHz-928MHz frequency range. As many as 16 full-duplex voice channels and connections to as many as 16 additional telephone or intercom lines can be configured. Portable units can make telephone calls or selectively call individual portables or groups of portables. Because the VoiceNet 2000 uses spread spectrum, no FCC site license is required to operate the system.

table units can make telephone calls or selectively call individual portables or groups of portables. Because the VoiceNet 2000 uses spread spectrum, no FCC site license is required to operate the system.

Circle (502) on Fast Fact Card

### Portable VHF monitor receiver covers 140MHz-170MHz range

The ARB-33B is a fully synthesized, portable VHF monitor receiver for the 140MHz to 170MHz range. Frequencies are selected with a thumb-wheel switch, and two channels may be recalled from memory quickly through a single switch.



The radio, from **Communications Specialists**, measures 5.12" x 2.45" x 1.02" and weighs 7 ounces. A rubber-flex antenna, an earphone, a BNC-to-SMA adapter and two AA batteries come with the receiver.

Circle (501) on Fast Fact Card

### UHF connectors fit Japanese cables



Two UHF series plugs, RFU-502 and RFU-502-1, fit 10D-2V and 12D-2V cables covered under Japan specification JISC-3501. The fittings, available from **RF Industries**, are both made of silver-plated machined brass with a Teflon dielectric and a gold-plated brass pin.

Circle (350) on Fast Fact Card

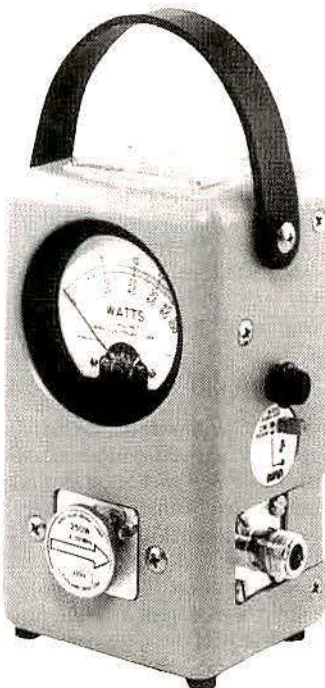
### Touch-screen console simplifies operator use, speeds activation

**CML Technologies** has introduced a touch-screen control CRT console for 9-1-1 and mobile radio dispatch. All of the features available with CML's standard consoles are incorporated into the new console, and most are activated by a single-touch action. The operator touches the feature or procedure to be activated on the screen, instead of employing keystrokes.

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Circle (63) on Fast Fact Card

## New products

### Personal communicator combines cellular phone, fax, pager & E-mail

Simon is a fully integrated, hand-held, cellular phone, wireless fax, pager, E-mail terminal, calendar, appointment scheduler, address book, calculator and pen-based note pad/sketch pad. The 18-ounce personal communicator was designed by IBM and is distributed in the



United States by **BellSouth Cellular**. The back-lit LCD functions both as a keypad and as a touch screen. Simon's PCMCIA card slot allows users to add a paging card to receive alphanumeric pages and electronic messages on a national, regional or local basis through **MobileComm**, BellSouth's paging company.

MobileComm will be the exclusive wireless messaging service provider for Simon. The PCMCIA messaging receiver is manufactured by **Motorola**.

Circle (352) on Fast Fact Card

### Cable-connection seal installs without the use of heat shrinking or tapes

Celwave's Great Seal is a cold shrink seal for cable connections designed to withstand hostile environments, aging and exposure. The rubber sleeves of the seal are dilated and mounted on a removable plastic core. The seal is installed by slipping it over a cable connection and pulling out the plastic support coil. The seal compresses instantly, even in subfreezing



weather, into a tight, form-fitting barrier that stops water migration.

Circle (353) on Fast Fact Card

### 800MHz trunking system includes programmable logic controller options

The Channel Sharing System (CSS) is an LTR-compatible, 800MHz trunking system. The CSS, developed by **Midland LMR**, uses fully synthesized 90W repeaters. It is available with a number of logic controller options, including dispatch-only and interconnect models. The controllers are fully programmable with a PC. They provide LTR logic, user validation and airtime accumulation in a single unit and permit real-time system monitoring. Inter-

connected CSS controllers have a built-in 1,200bps modem and do not require a dedicated phone line for modem access. The CSS includes a "ghost repeater" feature that allows 500 IDs per channel instead of the standard 250. Midland also has LTR-compatible CSS mobile radios that are programmable for as many as 10 trunked or conventional 800MHz systems, with as many as 10 groups or channels per system.

Circle (354) on Fast Fact Card

### Mic accessory aids communications under breathing apparatus conditions

The Loudmouth Speaker Mic (LSM) from **Earmark** is a voice amplifier with built-in radio interface, VOX or PTT, for use with self-contained breathing



apparatus (SCBA). The speaker mic comes with a detachable throat mic-and-earplug extension. The belt-clipped LSM can be interfaced with a portable radio, allowing the user the option to use either the throat mic or the speaker mic.

Circle (355) on Fast Fact Card

### Self-contained desktop console can direct as many as 12 base stations

The CommandPlus multistation desktop console is a self-contained unit that controls as many as 12 conventional base stations. The **Motorola** console offers features and capabilities typically found on larger consoles, including controlling multiple operations such as police, fire and public works from a single dispatch point. A variety of models control as many as

four, eight or 12 tone or dc base stations with as many as four frequencies and four PL/DPL per channel. Each console is equipped with an 8 x 40 character LCD, programmable function keys, instant transmit, intercom, alert tone, field programmability, built-in condenser mic, clock and VU meter.

Circle (356) on Fast Fact Card



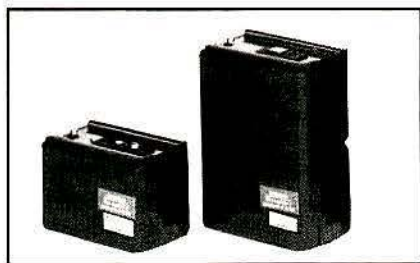
### Weather-resistant coaxial cable offers low loss, high shielding efficiency

The LMR-600 flexible coaxial communications cable from **Times Microwave Systems** has a foam polyethylene dielectric that provides loss of 2.5dB per 100 feet at 900MHz. LMR-600 cable yields more than 90dB shielding efficiency and  $\pm 10$  ppm per degree Celsius phase stability. Combining low loss with low cost, the cable is suitable as an antenna feeder in outdoor land mobile and cellular applications. Moisture protection is afforded by incorporating a polyethylene jacket with a vapor-sealed aluminum tape outer conductor. Available in bulk supply, LMR-600 coaxial cable is easy to terminate in the field. It is also available preterminated with Type N connectors. LMR cables are available in diameters from 0.24" through 1.67".

Circle (357) on Fast Fact Card



### NiCd models are added to inventory of battery replacements for portables



The nickel-cadmium replacement battery line from **Multiplier Industries** has been expanded to include several new rapid-charge batteries for portable radios.

Replacements, by manufacturer, include:

- ICOM America models CM-3, CM-9, CM-9A, CM-83 and CM-84.
- Kenwood USA models KNB-5A, KNB-6, KNB-6A, KNB-7, KNB-7A, KNB-3A and KNB-4.
- Midland LMR models 70-B16, 70-B21, 70-B19 and 70-B75.
- Motorola model NTN4596C for Saber radios.
- Standard models CNB-40 and CNB-242.
- Yaesu model FNB-11.

Circle (358) on Fast Fact Card

### Dc-to-ac inverter becomes available in three voltage input level versions

**Wilmore Electronics** has extended its Model 1603 series of 500-VA dc-to-ac inverters to include 24Vdc, 48Vdc and 130Vdc input versions.

The inverter provides a regulated 120Vac, 60Hz sine-wave output. The unit is designed to power telecommunications equipment and high-surge or nonlinear loads such as half-wave-rectified loads,



small motors or incandescent lamps.

Circle (359) on Fast Fact Card

### Briefcase-size mobile comm station links law enforcement teams, data

The **PacketCluster** briefcase-mounted mobile data station allows law enforcement users to send real-time messages, access criminal history, and create and upload reports. **PacketCluster Systems'** station consists of a notebook computer, a radio transceiver and an RF modem, all housed in a high-impact plastic case. A rechargeable internal battery and a built-in antenna allow the unit to be used without any external connections. For prolonged

surveillance or in-vehicle use, the unit can be plugged into a cigarette lighter socket and used with an external magnetic-mount antenna. The unit also can be outfitted with an automatic vehicle location (AVL) module. All data transmissions are encrypted to eliminate risk of unauthorized reception and to increase safety for the officers in the field.

Circle (360) on Fast Fact Card

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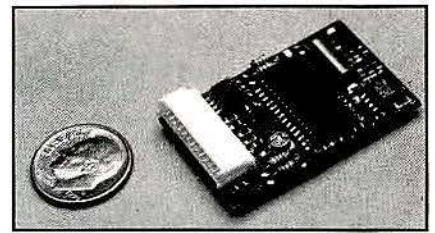
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Circle (65) on Fast Fact Card

## New products

### Module enables use of PTT switch to activate encryption, codekeys

The ST-25A Voice Encryption Module from Selectone offers several feature upgrades from the ST-25 module, including PTT switching for operating modes and codekeys and the addition of a fourth codekey. The "double-click" option allows a user to use two rapid clicks of the PTT or monitor switch to alternate between clear mode and encrypted mode, with an accompanying status tone. The ST-25A defaults to the clear mode if power is removed. The "quad click" option allows the user to change from one codekey to another by



four rapid clicks of the monitor or PTT switch.

Circle (361) on Fast Fact Card

### Cable fault locator computes return loss measurements, distance to fault



The Model 1205 Time Domain Reflectometer is a compact, multipurpose cable fault locator designed for field testing of all types of metallic paired cables. Model 1205, from **Riser-Bond Instruments**, features an RS-232 serial output port for computer interface that allows stored waveforms to be downloaded to a PC for post-storage evaluation and analysis. The unit has automatic and dual cursor operation that allows measurement between any two points on the waveform. It automatically calculates and displays return-loss measurements and distance to fault. Settings and cable conditions are shown on an LCD.

Circle (362) on Fast Fact Card

### Dispatch networking equipment allows single-customer RF linking

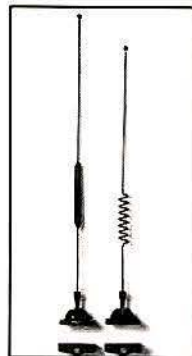
The Easy-Link Plus is a dispatch networking RF link from **IDA**. When used with two appropriately tuned half-duplex radios, the link provides single customer linking between the two radio systems. No

microwave, phone lines or additional frequencies are needed. Easy-Link Plus is designed to comply with FCC rulings on RF links between trunking systems. The link works for LTR to LTR, LTR to UHF/VHF, or UHF/VHF to UHF/VHF. Features include automatic path turnaround, muted or amplified receive-to-transmit audio paths, DTMF decoder for remote control, one auxilliary input and two auxilliary outputs.

Circle (363) on Fast Fact Card

### Pretuned solid-state coupling box reduces on-glass antenna's VSWR

The On-Glass IV mobile cellular antenna has a solid-state coupling box that achieves a VSWR of 1.5:1, compared to a previous ratio of 1.9:1. The coupling box optimizes the built-in counterpoise function to minimize currents on the coaxial cable. The solid-state design from **Allen Telecom Group** eliminates mechanical failures and noise generation. The coupling box is pretuned, eliminating post-installation tuning.



Circle (364) on Fast Fact Card

### AVL option for mobile terminals adds location to comm information

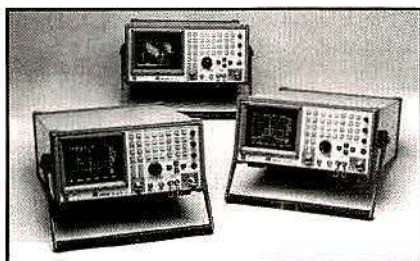
An automatic vehicle location (AVL) option from **ElectroCom Communications Systems** fits MDC-890 and MDT-870 mobile data terminals for public safety vehicles. The AVL option automatically determines vehicles' locations to within a few meters by reading information from a GPS receiver in the vehicle. Used in conjunction with Trimble's Placer AVL system, vehicle location is accurately reported within 2 meters to 5 meters when receiving a differential signal, or within 15 meters with a standard GPS signal.

Circle (365) on Fast Fact Card



## Spectrum analyzer provides speed for broad coverage of frequencies

The AN900 series spectrum analyzer from IFR Systems provides frequency coverage to 26.5GHz. Standard features on three models include a high-speed 200ns/div sweep with pre- and post-trigger capability, a sensitive FM-AM receiver with modulation measurement scales, resolution bandwidth of 3Hz-30MHz, and a +30dBm to -135dBm measurement range. Other standard features include a 5MHz digital storage oscilloscope, dc to 20kHz FFT analyzer and an automatic trace limits test function. For remote or field service use, all three models can be



powered from 12Vdc to 30Vdc sources or from an optional battery pack.

Circle (366) on Fast Fact Card

## LED-equipped antenna provides silent call signal for cellular phone

Centurion International's Silent Partner antenna for cellular phones has a small LED at the tip. The LED lights when a call is received, alerting the user if the ringer is

deactivated. Because the antenna always protrudes from the case, the Silent Partner is visible even if the phone is in the case and the keypad call signal is not visible. The light stays on until the call is completed. The Silent Partner option is offered on the CXS "Stubby" antenna, the CXP standard antenna, the CXF (fixed right angle) antenna and the CXR (adjustable 90°) antenna.

Circle (368) on Fast Fact Card

## Decoder offers control, reduced size



The Micro DTMF decoder from Bramco features front-panel switch convenience and remote decoder code programming. Programming options allow custom output and coding configurations. The decoder is 0.875"H x 2.6"W x 4.38"D. The unit will accept code lengths of one to nine digits.

Circle (369) on Fast Fact Card

## Portable two-way scanning radio provides 5W in small VHF package

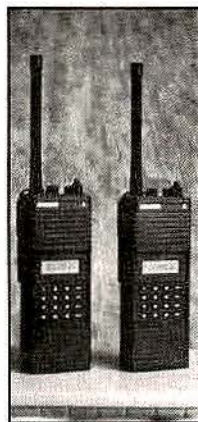
The 5W, 16-channel WHS150 portable scanning VHF (150MHz-174MHz) synthesized radio from Relm Communications features built-in CTCSS signaling and a full-function, DTMF-compatible keypad. Controls include LCD readout, channel access through the keypad or a top-panel rotary knob, scan button and channel add-delete button. With its battery, the WHS150 measures 6.4"H x 2.45"W x 1.3"D. Accessories include a drop-in battery charger, a speaker microphone and a leather case.

Circle (370) on Fast Fact Card



## Portable radios provide flexible channel-spacing, programmability

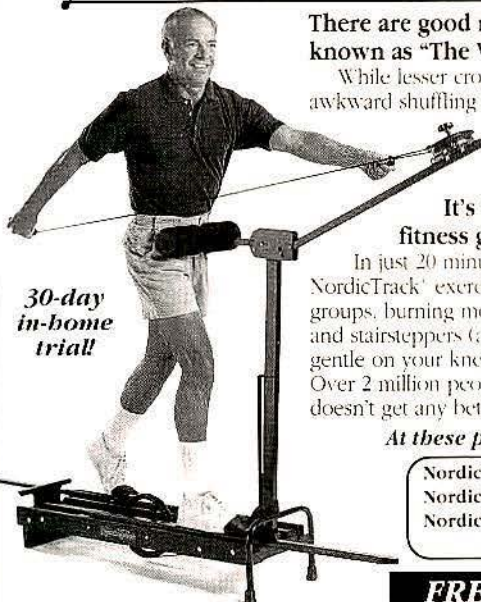
The Flex-Mode EPH radios from Bendix/King may be programmed to operate in channel-spacing requirements of 12.5/15kHz or 25/30kHz. The radios may be programmed with different spacing on each channel and/or by group. Already operable in the 25/30kHz system, the units can be programmed for the future requirements of 12.5/15kHz, easing the transition to NTIA standards for 12.5kHz channel spacing. The radios, with selectable RF power up to 5W, come in 16 combinations, ranging from 14 to 210 channels, and offer all the standard features of Bendix/King VHF portables. Models are available with Lexan plastic or metal cases.



Circle (367) on Fast Fact Card

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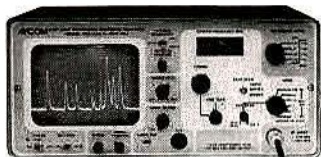
## AVCOM's New PSA-65A Portable Spectrum Analyzer

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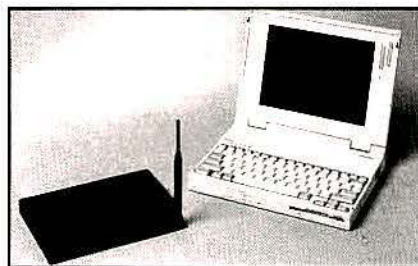
**Doug Hall Electronics**  
Voter Dept.  
815 E. Hudson St.  
Columbus, Ohio 43211  
(614) 261-8871

Circle (68) on Fast Fact Card

## New products

### Comm system provides mobile access to cellular digital packet data, fax

The Ubiquity 2000 is a cellular digital packet data (CDPD) communications system for use with IBM-compatible mobile computers. The NiCd battery-powered cellular system from **Pacific Communication Sciences** provides access to CDPD circuit-switched cellular data, cellular voice, cellular fax, wireline data, wireline fax and wireline voice. Users can attach a handset or headset to the unit to make telephone calls, dialing from the keyboard or from programs that automatically dial with modem commands. Accessories include an attachment holster, serial connection cable



and an ac adapter. The Ubiquity 2000 is Windows- and DOS-compatible.

Circle (371) on Fast Fact Card

### Cable adapter allows use of exterior antenna with digital phone

Allgon Mobile has an adapter that makes it possible to use an exterior antenna with an Ericsson GE digital phone. One end of the 20-inch-long RG-174 cable is fitted with an Allgon nipple connector; the other has the connector for the digital unit. The nipple connector allows for use with any of Allgon's mobile antennas, including: glass mounts, permanent mounts, magnetic mounts and trunk-lip mounts.

Circle (372) on Fast Fact Card



### Module enables addition of scanning mode to functions of non-scan pager

The Com-Tech SCII and SCII-P scanning modules enable scanning ability in Motorola Minitor II pagers. The modules from **Com-Tech Electronics** allow for normal alert function during the scanning mode. SCII is for nonpriority scan and

SCII-P is for priority scan. Putting the channel-select switch in the channel 2 position activates scanning and allows the user to listen to the transmissions on both frequencies. Scanning is deactivated by putting the unit in the channel 1, or bell, position. The modules operate in both Minitor II and SV models, but are not recommended for pagers covered by Motorola factory warranty.

Circle (373) on Fast Fact Card

### Hand-held radio is designed for use with 800MHz LTR trunked systems

The Viking XR-HL83 is a 2.5W hand-held radio designed for use with 800MHz LTR trunked radio systems. The handheld from **E.F. Johnson** features an LTR talkaround mode, a backlit keypad and a programmable, alphanumeric LCD. The Viking XR-HL83 is capable of 20 systems with 10 groups per system, with both system and group scan. As with other handhelds in the Viking XR line, the unit supports AmeriCom radio networking.

Circle (374) on Fast Fact Card



### UHF panel antennas give 65-degree horizontal coverage, low VSWR

Two UHF panel antennas for 410MHz-430MHz and 450MHz-470MHz offer horizontal coverage of 65° at 3dB points and a VSWR of 1.4:1. The antennas, from **Decibel Products**, offer 500W maximum input, vertical polarization and N-female termination. The DB691H65 model provides 7.5dBd gain (9.6dBi), a vertical beamwidth of 60° and a front-to-back ratio greater than 18dB. The DB692H65 model offers 8.9dBd gain (11dBi), a vertical beamwidth of 30° and a front-to-back ratio greater than 20dB. Options include flat wall mounts, a 7/16" DIN connector and mechanical downtilt via DB5081 brackets.

Circle (375) on Fast Fact Card

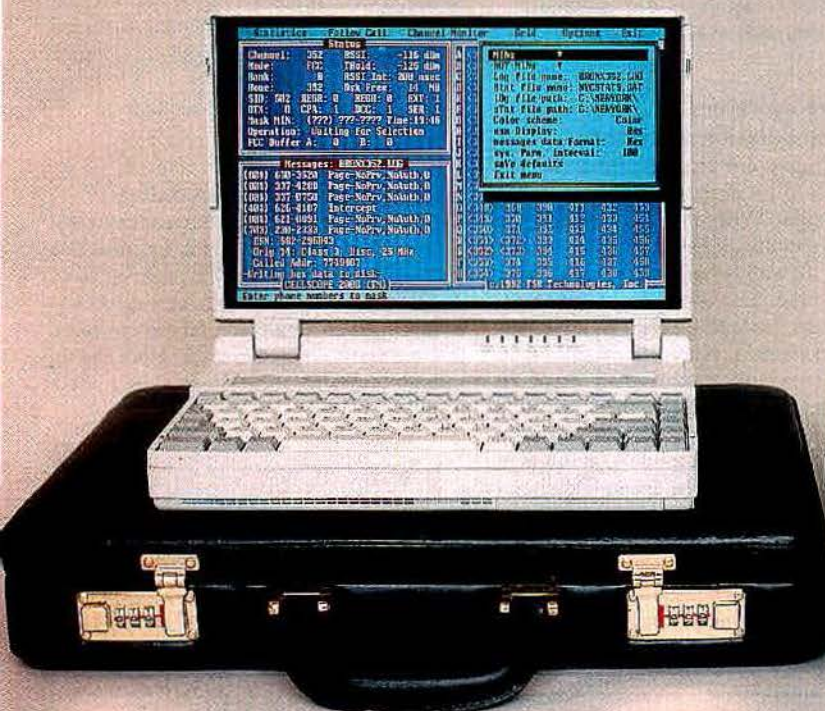




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### PAGETRACKER 2000

- Real time POCSSAG, GOLAY, and NEC page decoding
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- Integrates with a GPS receiver for service coverage mapping
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Circle (69) on Fast Fact Card



## Catalog describes microwave components

A 360-page catalog covers microwave components and instruments. Fifteen product categories are represented: mixers, sources, isolators and circulators, control products, mechanical switches, power dividers and hybrids, couplers, attenuators, adapters, terminations and phase shifters, waveguide, custom system components, radiation safety products, EMC test equipment and power measurement products. Standard practice in this catalog from **Loral Microwave-Narda** is to give each product group a two-page spread so that it is easier to assess all aspects of a product at a glance.

Circle (300) on Fast Fact Card

## Catalog features rechargeable batteries

A color catalog highlights Telepower batteries, Omnipower batteries, Telepower conditioner/analyzers and accessories from **JBro Batteries**. The catalog includes detailed photos of the batteries and accessories, and the product listings make it easier to match radios to the exact NiCd replacement battery. Included are listings of sealed lead, cordless telephone and pager batteries, as well as information on the Telepower conditioner/analyzer and Charger Plus battery maintenance systems.

Circle (301) on Fast Fact Card

## Catalog features communications information

"Wireless Communication Technology: 1994" is a 32-page, color catalog that includes books, directories, video and audio tapes, research studies, reports and software specifically focused on paging, mobile satellite, wireless data, cellular, PCS and networking. The catalog from **Quantum Publishing** applies to all levels of marketing, sales, general management, engineering and operations professionals.

Circle (302) on Fast Fact Card

## Brochure describes digital modulation analyzer

A six-page color brochure discusses the ME2627B digital modulation analyzer from **Anritsu Wiltron**. It covers all the pertinent specifications and features of the analyzer, as well as applications in which it can be used. The brochure shows available screens, including spectrum, eye pattern, constellation, phase/frequency error, power error and modulation error to supplement descriptions of the analyzer's capabilities. Information is provided on analysis parameters, mobile communications systems that can be tested and circuit component evaluation applications. Charts list all specifications, dimensions and weight, standard composition, options and software.

Circle (303) on Fast Fact Card

## Reference book covers PCS

The comprehensive Personal Communications Services (PCS) bidding book from **LCC** is based on data from the FCC database and the LCC MicroStore software package. Each chapter is devoted to one of the 47 MTAs and includes, block by block, a table and a plot of the existing OFS microwave links. The links with the bandwidths are divided into two categories: public safety links—"Protected," or "May be Protected," from involuntary relocation; and regular "Unprotected" links. Included in the book are MTA and BTA reference maps.

Circle (304) on Fast Fact Card

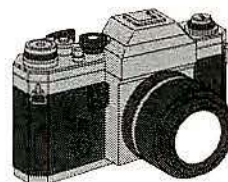
## Catalog highlights attenuators

An 84-page catalog features attenuators, RF switches, power dividers, terminations and related components. The catalog from **JFW Industries** includes new products such as power dividers, rotary attenuators, low-cost programmable attenuators and an introduction to the company's matrix switch capability.

Circle (305) on Fast Fact Card



**Do you have a photo you would like to see on the cover of *Mobile Radio Technology*?**



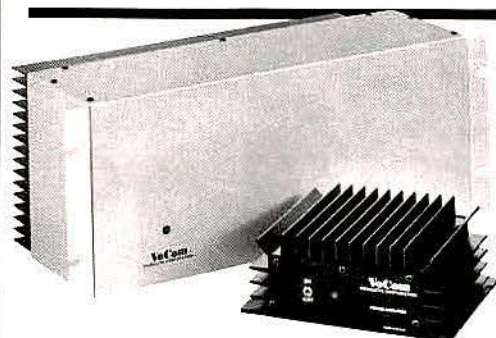
We are interested in photographs of facilities, installations or other graphic material relevant to the audience we serve. We welcome material from vendors, consultants, dealers, technicians, service-providers, end-users and others.

If you have a 35mm slide, transparency or other piece of art that you think would be worth consideration for our cover, please let us know. We would love to hear from you!

**Call or write:**  
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**Mobile Radio Technology**  
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Circle (66) on Fast Fact Card





**Chocolate**



**Hawthorne**



**Barnes**



**Isberg**

Changes at Celwave, Marlboro, NJ:

**Richard Chocolate**, international and technical sales manager, moves up to international sales and marketing director.

**Stephen Hawthorne** leaves Radio Call, Long Island, NY, as director of alphanumeric sales, to join Celwave as international region manager.

**Cheryl Barnes** exits Vartec, Dallas, as manager of district sales to join Power Conversion Products in its Richardson, TX, office as Southwest regional sales manager. The company's headquarters is in Crystal Lake, IL.

**Reuben Albert "Al" Isberg, P.E.**, of Wilsonville, OR, received the Alumni and Foundation Entrepreneur Award from the University of Northern Colorado, Greeley.

**Steven C. Bowles**, sales and marketing director for Centurion International, Lincoln, NE, advances to vice president of sales and marketing.

**William D. Baker** leaves Artisoft, Tucson, AZ, as vice president and chief financial officer to join Racotek, Minneapolis, as vice president of finance and administration and chief financial officer.

**Josef Shayovitch** departs Motorola, Schaumburg, IL, as director of data businesses for the Japan/Pacific division to join Ram Mobile Data, New York, as senior vice president of strategic business units.

Changes at Communications Associates, Joliet, IL:

**David A. Smith**, purchasing manager, advances to vice president of operations.

**Sue Stevens**, purchasing assistant, moves up to purchasing manager.

**Julie Nasenbeny** exits Creative Incentives, Oakbrook, IL, as operations manager to join Communications Associates as customer service manager.

**Pat McCormick** leaves Alliant Techsystems, formerly Honeywell, Wilmington, IL, as MRO buyer to become purchasing assistant for Communications Associates.

Changes at C.E.S., Winter Park, FL:

**Benjamin Stopka** leaves Harris Corporation's Melbourne, FL, facility, as director of international business development to join C.E.S. as vice president of marketing and sales.

**Robert E. Lowell** departs Aerotron-Repeco, Orlando, FL, as director of marketing and security products to become product planning manager at C.E.S.

**Jim Marion** leaves NEC America, Richardson, TX, as pager engineering manager to join Glenayre Electronics, Charlotte, NC, as RF products manager.



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Circle (70) on Fast Fact Card



**Technician licensing:**

Regarding your October 1993 editorial comment about technician licensing, I would offer the following:

In today's "real world," you cannot find a technician out of school who has the minimum abilities to understand electronics, or, worse, he cannot troubleshoot a single power supply or repair one without replacing every component on the board.

I am responsible for about 100 transmitters located across two-thirds of the state of South Carolina. My turnover in technicians is not large, but when I do lose someone, we interview as many as 30 applicants. Of those 30, usually none are licensed, and usually only one or two have any understanding of electronics. The situation is really bad.

We usually hire someone out of technical school, or the military, and insist that they begin studying for one of the general licenses—and obtain it within a year.

This keeps our technicians involved in study. If you don't encourage this, they become board-changers and never attain the abilities to understand, troubleshoot and repair electronics equipment.

The good old U.S.A. is really in trouble

when it comes to training decent technicians.

George D. Williams  
Communications Manager  
Central Electric Power Cooperative  
Columbia, SC

**Fast Fact Card comments:**

The toughest problem facing me on the job is that radio software programming is getting more complex and time-consuming.

Robert E. Griffin  
Chelsea Police Department  
Revere, MA

The toughest problems facing me on the job are obtaining realistic training on the latest-technology systems and balancing short-term budget planning with long-range, strategic requirements.

Gary A. Forehand  
Federal Aviation Administration  
Miami

The toughest problems facing me on the job are:

- interference with buildings in line-

of-sight with transmitters.

- software to drive the radio system.
- Steve J. Cormack  
Systems Programmer  
Irvine Ranch Water District  
Irvine, CA

The toughest problems facing me on the job are:

- safety in maintaining communication under fire.
- budget for equipment and radio gear upkeep.

Michael T. Erwin  
Firefighter  
Miami

The toughest problems facing me on the job are:

- non-contract customers who "drop in" without an appointment.
- getting parts and service manuals for Motorola cellular equipment.

Mark A. Malm  
Technician  
Bismarck, ND

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Please add the following information to your copy of the December 1993 issue's Buyers' Guide:

In the company addresses section, page 56:

American Towers and Structures  
P.O. Box 3241  
Sioux City, IA 51102  
712-252-0240  
800-369-0159  
Fax: 712-252-0371

Please add the company's name in the following product and services categories:

Shelters, page 40  
Tower Obstruction-marking lights, page 46  
Towers, page 46  
Tower installation, page 54

In the company addresses section, page 81:

Motorola Network Services Division  
1301 E. Algonquin Road, SH-4  
Schaumburg, IL 60196  
708-576-5484  
Fax: 708-576-8142

Please add the company's name in the services directory on page 54 under the "Tower space rental" heading.





# Mobile Radio Technology

The journal of mobile communications technology

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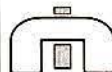
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Will assume budget management responsibility for nine markets, handle scheduling and changes orders, and coordinate installation. This includes responsibility for local contracts with subcontractors, program reviews, weekly reporting, inventory management, customer interface for status reviews, lease asset management, and order input and tracking.

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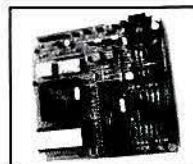
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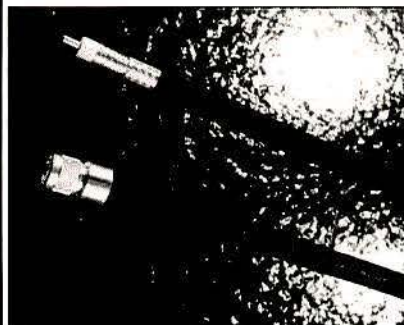


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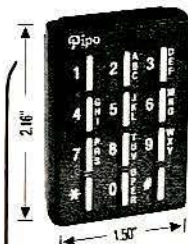
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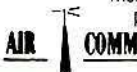
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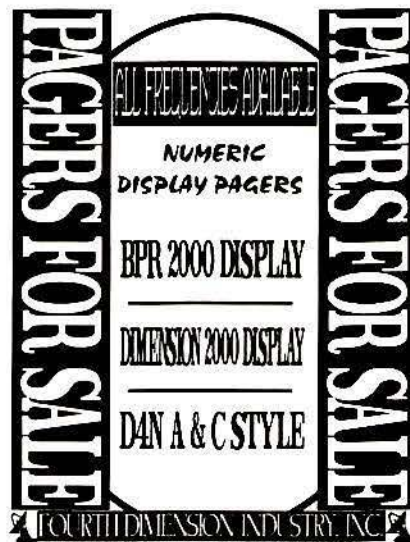
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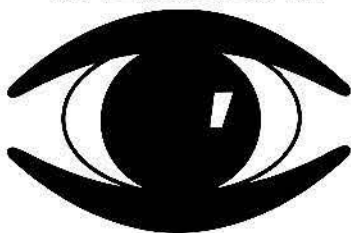
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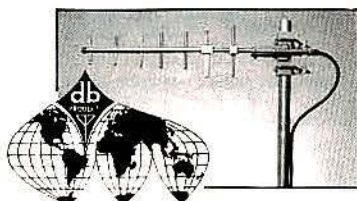
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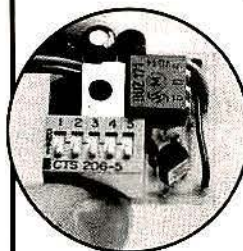
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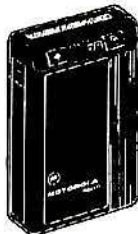
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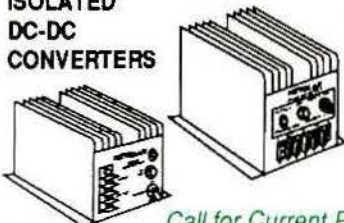
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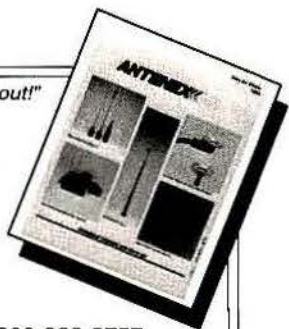
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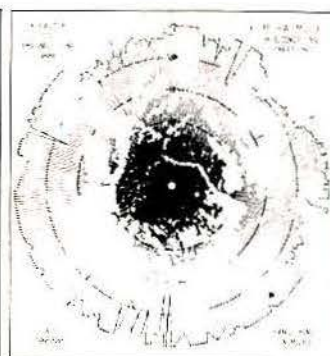
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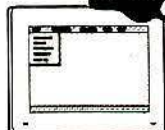
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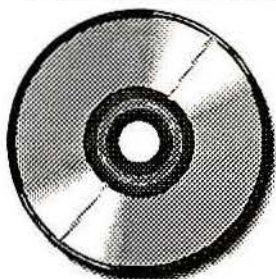


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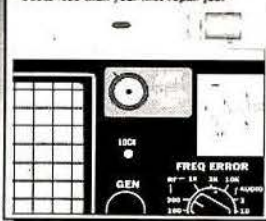
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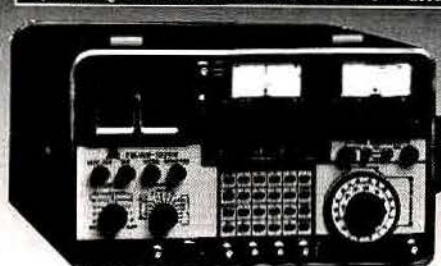
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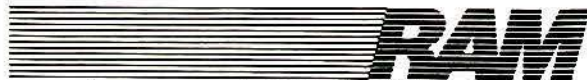
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Auto-Trac, Inc.	46	41	214-480-8145	Natcom Inc.	26,48	21,39	800-844-8287
Avcom of Virginia	70	67	804-794-2500	Natcom Inc.	88	104	800-844-8287
Avtec Inc.	16	13	803-892-2181	Norcomm Corp.	67	64	916-477-8400
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FTL-2011 VHF:

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FT-80C HF SSB Transceiver

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Watt (RF) (Not shown.)

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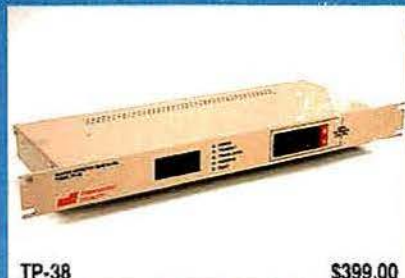
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